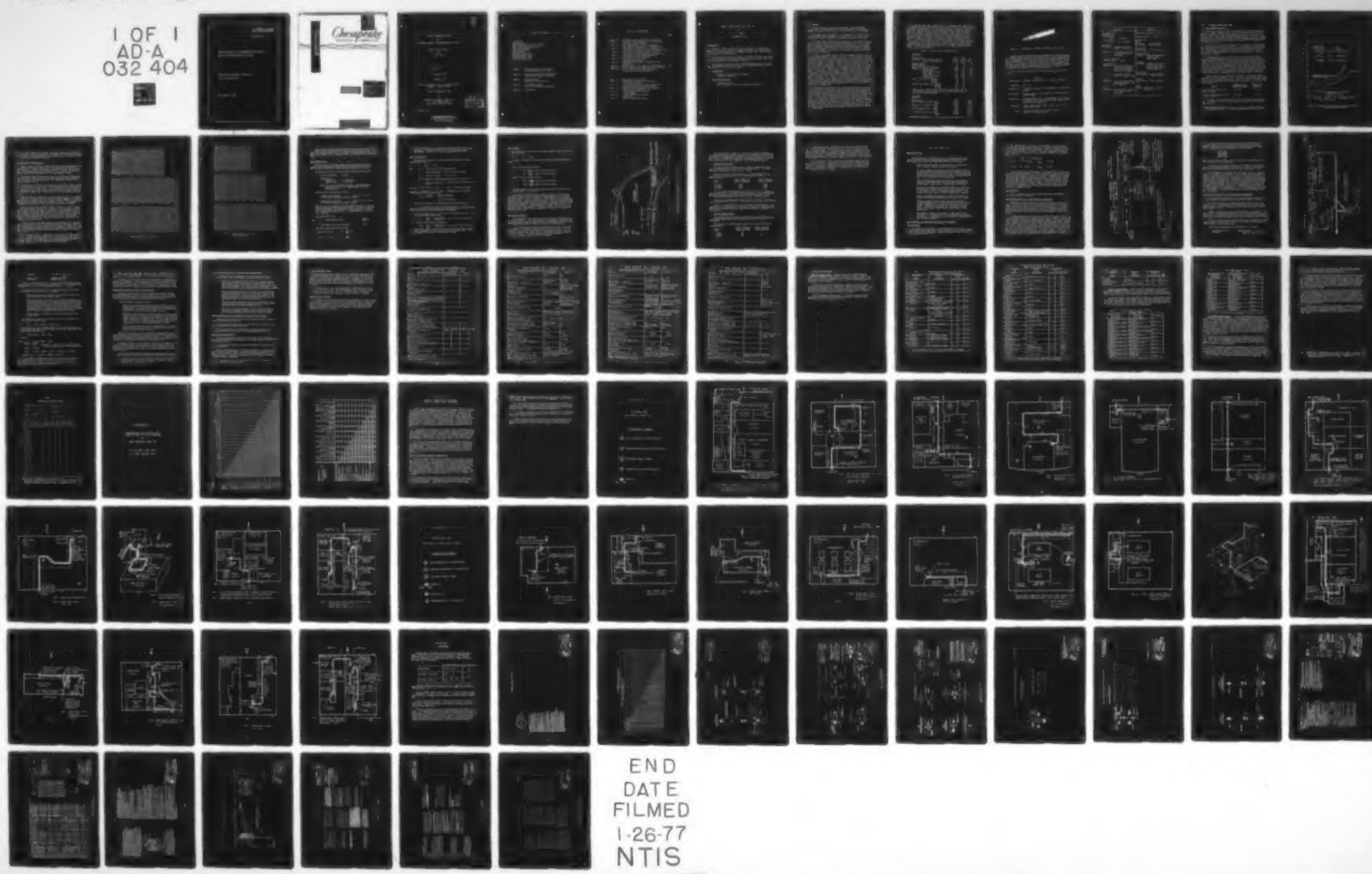
AD-A032 404 CHESAPEAKE INSTRUMENT CORP SHADY SIDE MD F/G 17/2
SHIPBOARD WIRELESS INTERCOMMUNICATION SYSTEM: RADIAX SYSTEM DES--ETC(U)
SEP 74 C J RUBIS N00024-74-C-1243

UNCLASSIFIED NL

1 OF 1
AD-A
032 404



END
DATE
FILMED
1-26-77
NTIS

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

AD-A032 404

SHIPBOARD WIRELESS INTERCOMMUNICATION SYSTEM: RADIAX SYSTEM DESIGN AND TEST PLAN

CHESAPEAKE INSTRUMENT CORPORATION
SHADY SIDE, MARYLAND

SEPTEMBER 3, 1974

(1)

INTERIM MEMORANDUM REPORT

FOR

SHIPBOARD WIRELESS INTERCOMMUNICATION SYSTEM

RADIAX SYSTEM DESIGN

AND

TEST PLAN

3 September 1974

Prepared for

Naval Ship Research and Development Center
Annapolis, Maryland 21402

Contract N00024-74-C-1243

by

Chesapeake Instrument Corporation
100 Atwell Road
Shady Side, Maryland 20867

C.I.C. Project 74154

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Radiax System Design and Test Plan

by

C. J. Rubis

3 September 1974

Introduction

The report, "Radiax Cable Installation Drawings" in fullfillment of Section 1.6B (a & b) was issued on 12 August 1974 following a detailed survey of the cable route aboard the U.S.S. PHARRIS, DE 1094, by a four-man engineering team on 1 and 2 August 1974.

On the basis of that survey and report the Radiax cable and other materials such as connectors, clamps, power splitters and terminations were ordered from the manufacturer during the week of August 12.

This report, the third and final interim memorandum report in fullfillment of requirements 1.6A(a) and 1.6B(c) on the "Shipboard Wireless Intercommunication System" provides the following:

System Design

Analysis of Radiax System Performance
Operational Capability

Test Plan Aboard Ship

Objectives of Test
Test Parameters, Technical Procedures and Equipment

System Design

A means of wireless communications between closed compartments of ships has been under investigation by the Navy for many years. The methods investigated, for example, include carrier current and induction loop schemes.

The method under investigation in this contract is to use a leaky or radiating coaxial cable transmission line which acts as an antenna for two-way wireless transmission between all compartments wired with the cable.

A wireless communications system independent of ship's power and using portable, commercially available hand-held transceivers (or other variations such as worn or built into an oxygen breathing apparatus) is an excellent means of emergency communications and for use by sound and security patrols aboard ship. Because of the complete electromagnetic shielding created by the steel compartments of ships, such an approach is normally not possible without special techniques.

Effective radio communications systems are being installed in buildings (with all metal framework), tunnels, and mines. In these cases the problem of RF-shielding environment has been solved by the use of leaky or radiating transmission lines. Electrically speaking, such a transmission line is nothing more than a conductor installed inside the building, tunnel or mine which provides ready access to RF energy. Leaky or radiating transmission lines used until very recently were mostly of the balanced open wire type. Radiating from this type of line depends on the unbalanced currents in the two conductors. This makes such lines very sensitive to mounting and the effects of nearby objects. For example, if the capacity to ground of one conductor differs from the other, the radiation increases but the attenuation also increases, in many cases to the point where the attenuation is a serious limit to the practical length of line. The line is also subject to the effects of dirt, deposits, and smoke. A new version of the leaky or radiating transmission line is the slotted coaxial cable designed to radiate and receive RF signals. It possesses very distinct advantages over the balanced line and makes feasible simple wireless intercompartment communications with very low transmitted power aboard ships at modest cost.

The approach analyzed here and in the subsequent shipboard evaluation in providing the ship with emergency communication between closed compartments is the utilization of a two-way radio (transceiver) system propagating low power RF energy through leaky or radiating transmission lines routed throughout the ship (or selected compartments), thereby creating an effective "free space" for those areas served while containing the transmission within the ship. It is important to recognize that the low power of this system and shielding of normal ships cables will not provide any detectable interference to other ship systems such as weapons, navigation, etc. This lack of interference to normal ship power and control circuits operating at DC, 400 Hz or 60 Hz power, results mainly from the extreme frequency separation between the communication system operating at about 140 MHz and the other low frequency ship systems.

The two-way radio units (a combination of transmitter and receiver with a rechargeable nickel-cadmium battery) are of the "walkie-talkie" type. These units are of rugged commercial construction and small size and can be carried about with little difficulty. A slotted coaxial cable, commercially known as Radiax*, is proposed as the radiating transmission line, shown in Figure 1. The slotted coaxial cable has slots cut out in its outer conductor. These slots allow a controlled portion of the transmitted RF signal to radiate along the entire length of the cable. Conversely, a signal transitted near the cable will couple into slots and be carried along the entire length of the cable. Such a cable functions as a continuous antenna. Performance relatively is independent of slot orientation, but a spacing of about 1/2 inch should be maintained between the cable and metal surfaces, otherwise poorer radiation results. The following tabulation (Table 1) is a summary of Radiax* slotted coaxial cable characteristics.

TABLE 1: Radiax* Cable Characteristics

Electrical

Nominal Size	1/2"	1/2"	7/8"
Type Number, with standard jacketing	RX4-1	RX4-3A	RX5-1
with Rulan jacketing	RX4-1R	RX4-3R	RX5-1R
Impedance, ohms	50	50	50
Velocity, percent	79	79	79
Typical VSWR 30, 150, 450 MHz	1.3	1.3	1.3
Attenuation, db/100 feet, 30 MHz	0.45	0.9	0.24
db/100 metres	1.47	2.95	0.78
db/100 feet, 150 MHz	1.1	1.9	0.6
db/100 metres	3.60	6.23	0.96
db/100 feet, 450 MHz	2.1	4.0	1.2
db/100 metres	6.89	13.12	3.93
Coupling Loss $\pm$10 db at 30 MHz	85	67	--
150 MHz	75	57	70
450 MHz	85	61	80
Average Power Rating, kw at 30 MHz	4.3	4.3	--
150 MHz	1.7	1.7	3.7
450 MHz	0.9	0.9	1.9

(Coupling loss is the average difference between signal level in the cable and the signal received by a zero dbd gain antenna 20 feet (6.1 metres) from the cable.)

Mechanical

Nominal size	1/2"	7/8"
Outer Conductor diameter inches	0.540	0.980
(mm)	(13.8)	(24.9)
Diameter, over jacket, inches	0.620	1.10
(mm)	(15.8)	(27.8)
Minimum Bending Radius, Inches	5.0	10
(mm)	(127)	(254)
Cable Weight, pounds per foot	0.160	0.44
(kg/m)	(0.238)	(0.655)

*Trade name for radiating coaxial cable manufactured by Andrew Corp, Chicago, Ill.

Figure 1:- Photograph of Radiax* Radiating Coaxial Cable

Two-way, hand-held transceivers are recommended for shipboard communications purposes because of their light weight, small size, and rugged construction. The weights of these units vary from 25 to 43 ounces, depending upon type and manufacturer. The sizes vary from 1-13/16 x 3-3/8 x 9-3/4 to 1-7/32 x 2-3/4 x 6-15/16 inches. The units are usually carried by attaching their carrying cases to the belt, not unlike a gun holster. The power is supplied by internal nickel-cadmium battery pack which is fully rechargeable and typically provides up to 8 hours of intermittent operation.

Table 2 shows the characteristics for a typical transceiver, Motorola HT-220.

Table 2.

Manufacturer's Published Characteristics for HT-220 Transceiver

Frequency:	136 - 174
Power Source:	(1) Mercury battery, or (2) Rechargeable Nickel-Cadmium battery
Battery Drain:	Standby (15V dc) 4.3 mA; Receive (15 Vdc) 65mA; Transmit (15V dc) 850mA
Battery Life:	Mercury Battery: 27 hrs., Nicad Battery: 8 hrs. (Based on 5% transmit, 5% receive with rated audio output and 90% standby in 5-watt position.)
Dimensions:	(Less antenna, knobs) HxWxD: 7.58" x 2.75" x 1.69" (192 x 70 x 43 mm)
Weight:	With Mercury Battery: 29.5 ounces (836g); with Nicad Battery: 27.6 ounces (782g).

Table 2 (cont'd)

Transmitter	Receiver
RF Output Power (Switchable): Nicad Batt @ 15V: 1 or 5 watts Merc Batt @ 12.7V: 0.4 or 2.5 watts	Modulation Acceptance: ±7 kHz
	Channel Spacing: 25 kHz
Frequency Stability: ±0.0005% from -30°C to +60°C (+25°C ref.)	Sensitivity - 20 db Quieting: 0.35μV maximum 12 db SINAD: 0.25μV maximum
Modulation: 16F3: ±5 kHz deviation for 100% modulation @ 1000 Hz	Selectivity -(EIA) SINAD: 70 db at ±25 kHz
Crystal Frequency Multiplication: 9 times	Intermodulation Products: More than 60 db down at adjacent channel (EIA) SINAD
Spurious and Harmonics: More than 50 db below carrier in 5W position. More than 43 db below carrier in 1W position.	Frequency Stability: ±0.0010% from -30°C to + 50°C (+25°C ref.) ±0.0015% from -50°C to +60°C (+25°C ref.)
FM Noise: 40 db below ±3.3 kHz deviation at 1000 Hz tone	Spurious and Image Rejection: More than 50 db below carrier
Audio Response: +1 db,-3 db from a 6 db/ octave pre-emphasis from 300 to 3000 Hz	Squelch Sensitivity: 0.18μV, adjustable.
Audio Distortion: Less than 10% at 1000 Hz 2/3 maximum rate of deviation.	Audio Output: 500 mW at less than 10% distortion.

Analysis of Radiax* System Performance

Cable Selection Criteria

Three types of Radiax* cable are manufactured by the Andrew Corporation (Table 1). These are: RX4-1 (1/2"), RX4-3 (1/2") and RX5-1 (7/8"). It is noted from the data on coupling and attenuation losses that if the attenuation loss due to cable length is low, the coupling loss is high and vice versa. In other words, as the cable radiates more energy thereby decreasing coupling loss the penalty is additional attenuation loss resulting from energy leaving the cable as radiation.

The choice of cable type is determined by the length of coverage needed, the coupling loss and other considerations. By computing the total attenuation plus coupling loss versus length of cable for the three different cables, it is apparent there are several crossover points as expected. Figure 2 shows a plot of the attenuation plus one way coupling loss for three different cables at 150 MHz.

Considering just the 1/2" cables, RX4-1 is a low radiation type of cable having a 75 db one-way coupling loss and an attenuation of 1.1 db/100 feet. Another type of 1/2" cable is the RX4-3 which is a high radiation type having a lower coupling loss (57 db) but a higher attenuation per foot of cable (1.9 db/100 ft.). For short lengths the high radiation cable is preferred since the sum of coupling and attenuation loss is much less than for the low radiation cable. For example, at 100 feet the total losses are about 59 db versus 76 db, a difference of 17 db. For the 1/2" cables the crossover point occurs at 2,250 feet. Thus, for coverage less than 2,250 feet RX4-3 gives lower total losses while for lengths longer than 2,250 feet RX4-1 is preferred.

Cable length and attenuation charts (Appendix 1) have been prepared for both Route #1 (aft) and Route #2 (fwd), based on the Radiax Cable Installation Plan[1] for the DE 1094 destroyer escort. From these charts the greatest length of cable and attenuation from any compartment to another is as follows (using RX4-3 cables):

Route	Maximum Inter-Compartment Length	Maximum Cable Attenuation
#1 (aft), Passage Main Deck to Shaft Alley No. 1	572 feet	10.4 db
#2 (fwd), Damage Control Central to Shaft Alley No. 1	419 feet	8.0 db

Note that the relationship between cable length and cable attenuation is just 1.9 db/100 ft. with no account taken of the 3 db loss when encountering a power splitter.

[1]"Interim Memorandum Report for Shipboard Wireless Intercommunication System, Cable Installation Plan", 12 Aug 1974, Chesapeake Instrument Corporation

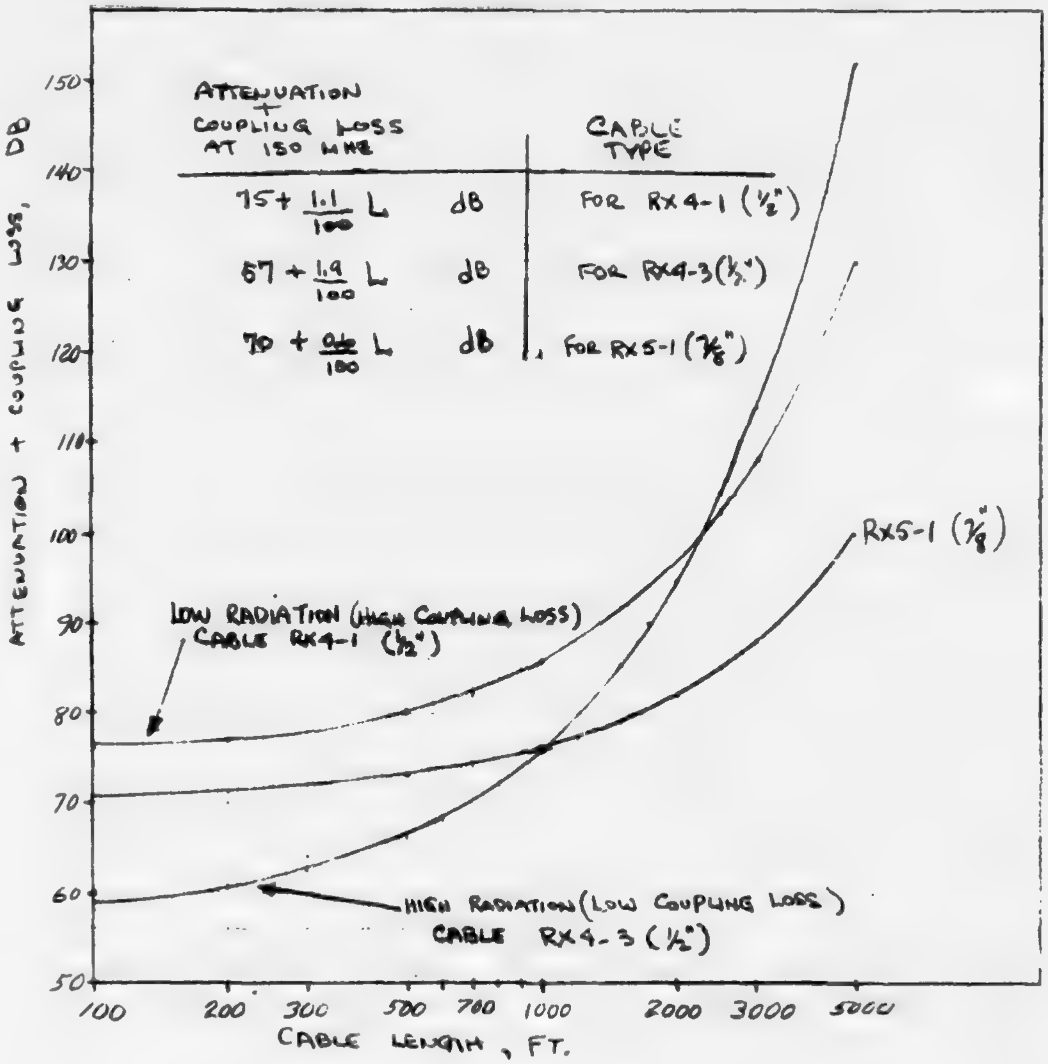


Figure 2: Attenuation plus Coupling Loss Versus Cable Length for Radiax* Cable at 150 MHz.

The total lengths are well below 2,250 feet, hence the use of the high radiation cable (RX4-3) is preferred. For example, at 572 feet the coupling plus attenuation loss indicates the high radiation cable is superior by about 13 db over the low radiation 1/2" cable.

Cable Radiation Characteristics

Recent tests (June 1974) on Radiax cable by the Andrew Corporation have indicated that radiation characteristics are affected by the proximity of metal surfaces. The type of cable most affected is the high radiation model RX4-3 with progressively decreasing effect for lower radiation cable which employs smaller size leakage holes for the electromagnetic energy.

Experimental data on coupling loss (db) versus operating frequency have been obtained for RX403 cable using 102-foot lengths.and various conditions of metal proximity to the Radiax cable. This experimental plotted data is shown in figures 3 and 4.

Interpretation of figures 3 indicates large variations in cable coupling loss with frequency when the cable is in direct contact with a metal surface (in this case, a 1.6" diameter pipe). These variations can be as high as 25 db. However, the mean of the coupling loss peaks in the frequency range from 120 to 260 MHz is about 7 db. In the vicinity of 140 MHz the loss is about 1.5 db.

When the Radiax is removed 1/2" from the same metal pipe (1.6" diameter) the variations in coupling loss with frequency almost disappears (Figure 4). What remains is a coupling loss with an almost smooth variation with frequency. Coupling loss gradually increases as frequency increases. For example, at 140 MHz the loss is about 1.5 db which increases to 2.0 db at 260 MHz.

When the Radiax cable (102-foot length) is taped to a 4-1/2" diameter pipe the coupling loss variation with frequency is also pronounced, but with a mean of the coupling loss peaks of about 12 db in the frequency range of 120 to 260 MHz. At 140 MHz, the coupling loss is about 5.0 db. As with the smaller diameter pipe, when the Radiax is moved 1/2" away from the pipe, the large variations disappear leaving a loss which gradually increases with frequency. At 140 MHz and 1/2" spacing from the 4-1/2" diameter pipe, the coupling loss is about 1.8 db.

If the results of these measurements can be extrapolated to conditions aboard ship where the Radiax will follow armored metal cableways, metal bulkheads, catwalks and structural members then the problem of coupling loss variation with frequency and metal proximity can be essentially reduced to a minor loss of a few decibels by mounting the Radiax cable at least 1/2" from any metal surface.

No polarization effect is expected to take place for 150 MHz shipboard operation. Indoors, the polarization effect will be cancelled due to the multiple reflections from compartment walls, overheads, decks, and equipment contained therein. This effect has been confirmed by measurements made inside buildings; sometimes 2 or 3 db difference has been detected.

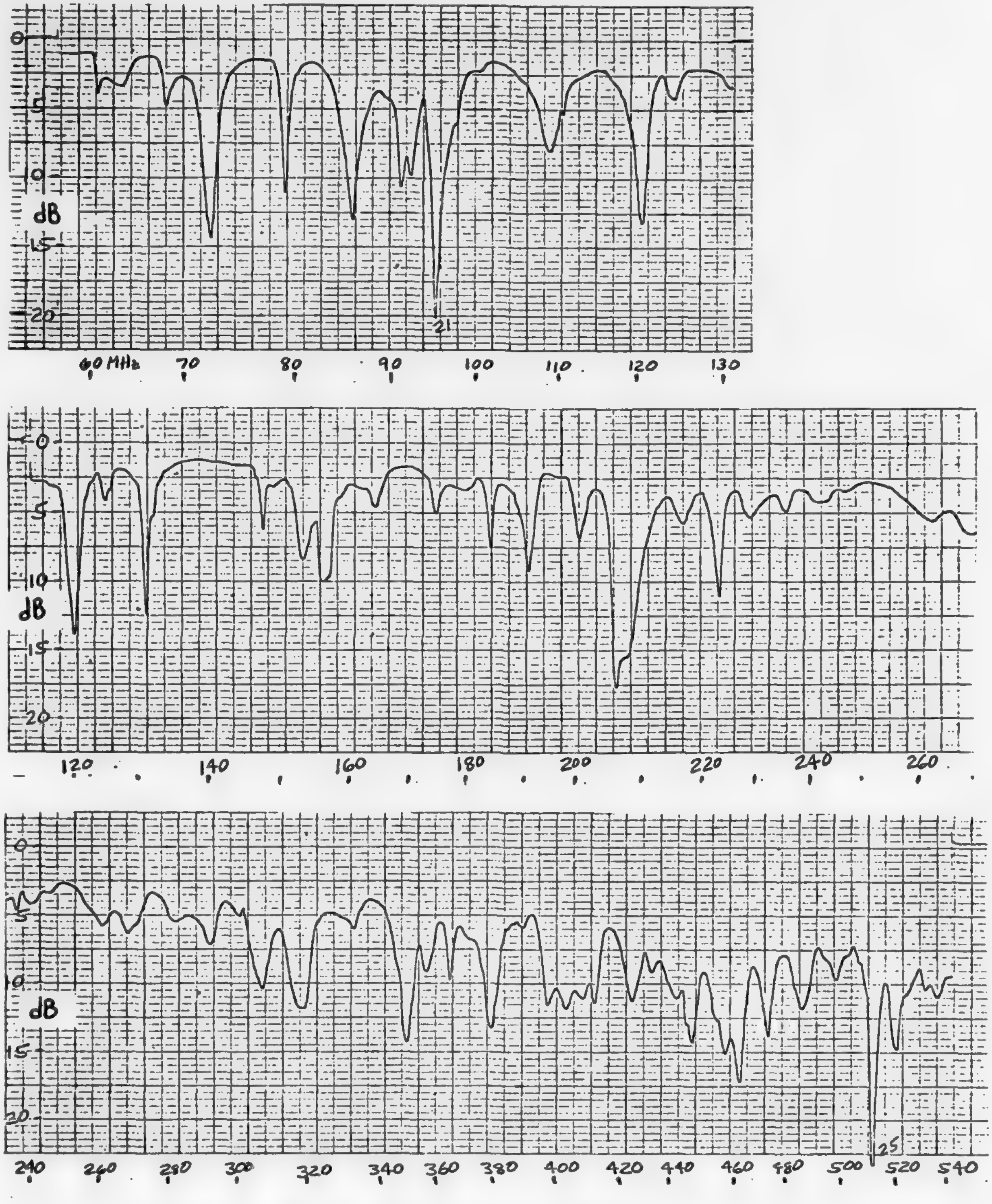


Figure 3:- Additional Coupling Loss vs. Frequency for RX4-3 Radiax Cable Taped to 1.6" Diameter Pipe

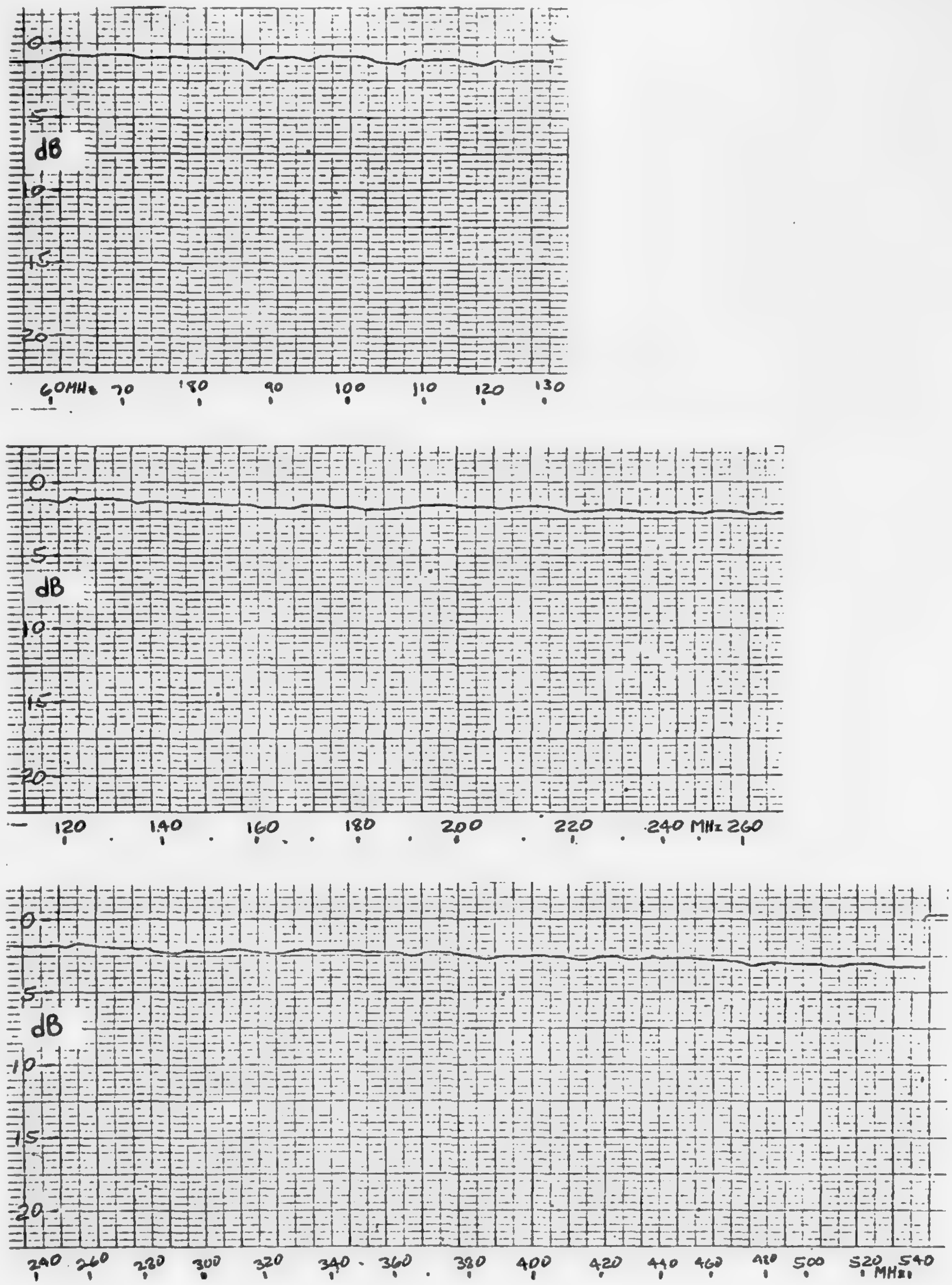


Figure 4:- Additional Coupling Loss vs. Frequency for RX4-3 Radiax Cable Spaced 1/2" from 1.6" Diameter Pipe

When the Radiax cable penetrates bulkheads through steel stuffing tubes or is effectively shielded by obstructing metal objects, that portion of the Radiax cable becomes ineffective as a radiator of electromagnetic energy. However, such shielding will not adversely affect other portions of the radiating cable.

Total System Losses

The major part of the total system losses are the coupling losses in transferring electromagnetic energy from the slotted coaxial cable to the receiver input terminals and from the transmitter output to the cable.

The system loss calculations are based on the following conditions:

Operating Frequency 150 MHz

Cable (RX4-3)
Attenuation = 1.9 db/100 ft.
Coupling Loss: = 57 db $\pm$10 db

Unity Gain (0 db) transceiver antennas. During measurements any antenna loss will be lumped together with the coupling loss.

System losses are tabulated as follows:

Coupling loss (one way) (hard wired transmitter, wireless receiver) $57 + 10 + 5 = 72$ db

Coupling loss (two way) (wireless transmitter, wireless receiver) $2(57 + 10 + 5) = 144$ db.

Where 10 db is an allowance for field strength variations. Variations of $\pm$10 db have been observed when moving only a few feet in any direction from the Radiax, facing toward vs. facing away from the Radiax with a hand-held portable unit, etc. A metal proximity loss of 5.0 db is also assumed.

Cable Attenuation loss $= \frac{1.9L}{100}$ db

where L = Cable length in feet

Power Splitter Loss (one splitter) = 3 db

Thus, the total system losses are as follows:

$$\text{System Loss (one way)} = 75 + \frac{1.9L}{100} \text{ db}$$

$$\text{System Loss (two way)} = 147 + \frac{1.9L}{100} \text{ db}$$

Note: It is anticipated by the manufacturer that the coupling loss of 67 db obtained in a non-metallic enclosure is pessimistic for steel enclosed compartments. Lower coupling losses are expected aboard ship.

Receiver Sensitivity

The receiver sensitivity is estimated from the equation for minimum detectable power, P_{min}.

$$P_{min} = kTBF$$

where $kT = 4.05 \times 10^{-21}$ (for room temperature)

B = receiver bandwidth = $2(f_m + \Delta f)$ for FM receiver

$B = 2(3.0 \text{ kHz} + 5 \text{ kHz}) = 16 \times 10^3$ Hz

(This bandwidth is approximately equivalent to 50 kHz at -70 db)

F = receiver noise figure = 4(6 db) for field-effect transistor input.

Then $P_{min} = 4.05 \times 10^{-21} \times 16 \times 10^3 \times 4 = 2.59 \times 10^{-16}$ watts (-156 dbw)

Using P_{min} = -156 dbw (2.59×10^{-16} watts), corresponds to a voltage level at a 50-Ohm receiver input resistance of

$$v_{min} = \sqrt{P_{min}R} = \sqrt{2.59 \times 10^{-16} \times 50}$$

$$= 0.11 \times 10^{-6} v (0.11 \mu v).$$

The receiver sensitivity for the Motorola HT-220 transceiver is:

.35μv maximum for 20 db of quieting (Table 2). The value of .35μv compares well with the above approximate calculation giving .11μv for a unity signal to noise ratio with no FM threshold improvement.

A receiver sensitivity of .35μv across a 50-ohm receiver input is equivalent to an input power threshold P_{RT}.

$$P_{RT} = \frac{V_{in}^2}{R_{in}} = \frac{(.35 \times 10^{-6})^2}{50} = 2.45 \times 10^{-15} \text{ watts (-146 dbw)}$$

Across a 75-ohm receiver input the power is:

$$P_{RT} = \frac{V_{in}^2}{R_{in}} = \frac{(.35 \times 10^{-6})^2}{75} = 1.63 \times 10^{-15} \text{ watts (-148 dbw)}$$

The receiver input resistance is variable in the approximate range of 50 to 75 ohms depending on input tuning transformer slug position. For purposes of analysis sensitivity of -146 dbw will be used.

Expected Range

The signal power available at the receiver terminals after system losses is given as follows:

$$P_R = P_T - P_{Loss}$$

In terms of decibels of power below one watt (dbw) the above equation becomes:

(For 1 watt (+0dbw) transmitted power)

$$P_R = -(75 + \frac{1.9L}{100}) \text{ dbw, for one way wireless}$$

$$P_R = -(147 + \frac{1.9L}{100}) \text{ dbw, for two way wireless}$$

(For 5 watts (+7 dbw) transmitted power)

$$P_R = -(68 + \frac{1.9L}{100}) \text{ dbw, for one way wireless}$$

$$P_R = -(140 + \frac{1.9L}{100}) \text{ dbw, for two way wireless}$$

The above equations for received power have been plotted as a function of the cable length, L, in Figure 5.

Two receiver threshold levels are shown in Figure 5. One for P_{RT} = -146 dbw equivalent to 20 db of quieting and the other at P_{RT} = -156 dbw equivalent to about 10 db of quieting. At 100% modulation, the frequency modulation index is $\Delta f/f_m$ = 5 kHz/3 kHz = 1.67, where Δf = maximum frequency deviation and f_m = maximum modulating frequency. The transition between narrowband and wideband FM is usually specified at a modulation index of $1/\sqrt{3} \approx 0.6$ and the FM threshold is expected to occur somewhat below 10 db. It is expected that for the condition of modulation index = 1.67, this FM receiver system will have a lowest receiver threshold of -156 dbw for a quieting in the vicinity of 10 db.

Operational Capability

The estimates for the coupling losses are the most unpredictable portion of the range analysis. The coupling loss of 57 db between transceivers and the Radiax cable is based on the manufacturer's measurements made at distances of 20 feet from the cable in non-metallic rooms and away from metal.

In the confined spaces aboard a destroyer escort 20 feet is a significant distance. For example, the approximate length and width of the fire room, the largest space in the DE-1094, is about 41 by 45 feet. Once the cable is installed, the largest and most unpredictable portion of the system loss is the location and orientation of the portable transceiver. A 10 db variation in one-way coupling loss may be expected.

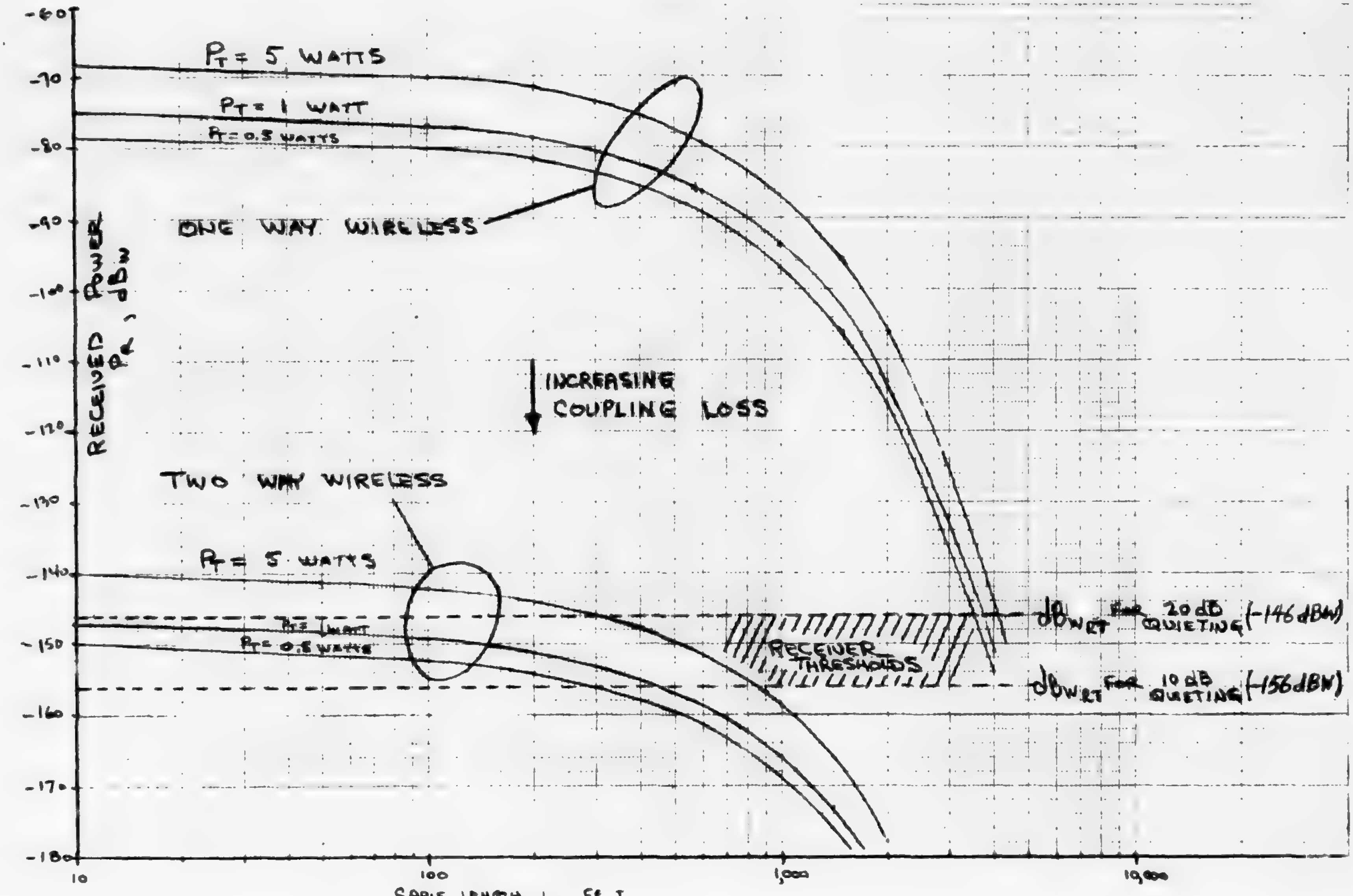


Figure 5:- Received Power versus Cable Length for Various Conditions of Transmitted Power and System Loss.

The calculations include an allowance of 10 db for antenna orientation, reflections, obstructions, etc. and a 5 db allowance for some increase in coupling loss expected when the Radiax is mounted close (within 1/2") to a metal surface. It should be noted that in the two-way wireless transmission case all the above losses are doubled in obtaining range estimates.

One-Way Wireless System

The one-way wireless system is one in which one communicating party (usually a base station) is hard wired to the Radiax cable. This removes from the system a coupling loss of 57 + 10 + 5 = 72 db.

Under the conditions described earlier, the range estimate for 0.5, 1.0 and 5.0 watts of transmitted power can be determined from Figure 5. Thus, the expected range is:

Power	Cable Length (ft) @ P_{RT} = -146 dbw	Cable Length (ft) @ P_{RT} = -156 dbw
0.5 watts	3,580	4,100
1.0 watts	3,740	4,260
5.0 watts	4,100	4,630

For the longest cable length in any route (Route #1, aft, passage main deck to shaft alley no. 1) the distance is 572 feet. For this condition the estimated signal reserve for 20 db of threshold quieting is 146 - 86 = 60 db for 1 watt transmitted power and 67 db for 5 watts of transmitted power.

Even with both routes tied together (572 feet + 419 feet = 991 feet), the signal reserve is still 146 - 94 = 52 db for 1 watt and 59 db for 5 watts.

Thus, it is expected that for one-way wireless transmissions all wired compartments can be reached with a high signal reserve if a reasonable effort is made by the wireless operator to come within an unobstructed range of the Radiax cable.

Two-Way Wireless System

The two-way wireless system as the name implies uses the Radiax cable as an antenna between two or more transceivers, none of which are hard wired to the cable.

From Figure 5 the expected cable range is for 0.5, 1.0 and 5.0 watts radiated power:

Power	Cable Length (ft) @ P_{RT} = -156 dbw	Cable Length (ft) @ P_{RT} = -146 dbw
0.5 watt	316	0
1.0 watts	470	0
5.0 watts	842	316

From the calculations, it appears that success of a two-way wireless Radiax system using low transmitter power will require a high sensitivity receiver (PRT$\approx$ -156dbw). In these calculations several assumed loss factors may be too conservative for shipboard communications and therefore, the high receiver sensitivity requirement may be somewhat alleviated. Specifically, quieting was assumed for entertainment quality reception (20 db) and no signal strength "boost" was given for two-way communication within a steel enclosure.

It is significant to note that from an operational viewpoint the need for a two-way wireless is almost always for short communicating distances. Examples are fire parties communicating with each other in adjacent compartments, or roving patrols communicating with personnel in compartments with no hardwired connections to Radiax. In extreme situations, message relay via the base station(s) is possible.

TEST PLAN ABOARD SHIP

Objectives of Test

The objectives of the shipboard wireless intercommunication system tests using Radiax cable wired through two selected routes and various compartments of a DE-1052 class destroyer escort are as follows:

1. Determine quantitatively the received signal strengths available in various locations served by the cable.

   The signal strength measurements should preferably be obtained so that computations can be readily made on coupling loss, cable attenuation loss and receiver sensitivity to evaluate range and overall performance under conditions normally encountered aboard ship using the Radiax cable and transceivers.

   Signal strength measurements should include received power in the major compartments especially when cable distance, transmitted power or configuration creates marginal performance.

2. Determine qualitatively the operational capability of the Radiax as an internal communications system noting such factors as: intelligibility, noise, interference between channels, interference from other sources, flexibility and ease of operation.

3. Conduct interference measurements and tests to determine the extent of interference between Radiax and other ship systems.

   These measurements should include signal levels present at portable transceivers and on passive Radiax cable at the communications frequency due to pickup from ship transmitters and radars. During active operation the interference of these sources to the Radiax communications system should be noted qualitatively.

   Measurements of Radiax interference to other systems should include signal strength data in various compartments and passageways that do not have Radiax cable, particularly compartments on the main deck and above.

Test Parameters, Instrumentation and Technical Procedures

Test Parameters

The quantitative measurements to be performed are mainly data on signal strength under various conditions of transmitted power, location, transceiver orientation and local configuration changes (opening and closing of doors and hatches, personnel traffic, etc.).

One of the easiest and most direct measurements of signal strength is to measure the received power directly e.g., in terms of decibels below one watt. The received power ratio in decibels relative to 1.0 watt is given by $10 \log 1.0/P_R = 10 [\log 1 - \log P_R] = -10 \log P_R$. Neglecting the negative sign (since $\log P_R$ is negative for $P_R<1$, positive for $P_R>1$), the received power in dbw is:

$$P_{dbw} = 10 \log P_{R(watts)}$$

e.g. For $P_R = 2 \times 10^{-12}$ watts $\quad P_{R_{dbw}} = -117$ dbw

For $P_R = 5.0$ watts $\quad P_{R_{dbw}} = +7$ dbw

If the received power measurements are all made directly in dbw using calibrated transceivers there is no need for additional computations involving antenna aperture, antenna efficiency and conversion between field strengths in µv/m to received power at the input terminals. Furthermore, the computations involving tradeoffs between transmitter power, coupling loss, cable attenuation loss, receiver sensitivity, etc. are extremely simple involving only the addition or subtraction of decibels. In fact, these results are all graphically displayed in Figure 5, where changes in coupling or other losses can be accounted for by sliding the curves up or down relative to the receiver threahold levels.

Instrumentation

A block diagram of the signal strength measuring instrumentation and calibration is given in Figure 6.

Instrument Calibration for Signal Strength Measurements

The Motorola HT-220 transceiver should be modified to measure the first stage IF amplifier limiter current by installing a connector on the case connected to the limiter output. An internal jack mounted on a circuit board inside the case for use as a test point is already connected to the first stage limiter through an RF detector providing a DC voltage proportional to the limiter current. Usually a 0 to 50 range microammeter is used for this purpose.

A signal generator set to the nominal operating frequency for the transceivers (140 MHz) should be connected directly into the receiver input through a matching transformer after disconnecting the antenna. The signal generator output voltage or attenuator setting should then be decreased until a reading in the linear portion of the limiter current characteristics well below the knee of the limiter curve is obtained. Readings should then be taken of both the limiter current and the input voltage for several points along the linear portion of the limiter characteristic. The input voltage is then converted to input power using the relationships $P_R = V_{in}^2/R_{in}$ and $db_{WR} = 10 \log P_R$. The input resistance may have to be determined by measurement or from manufacturers specifications, but it is expected to be in the range of 50 to 75 Ohms.

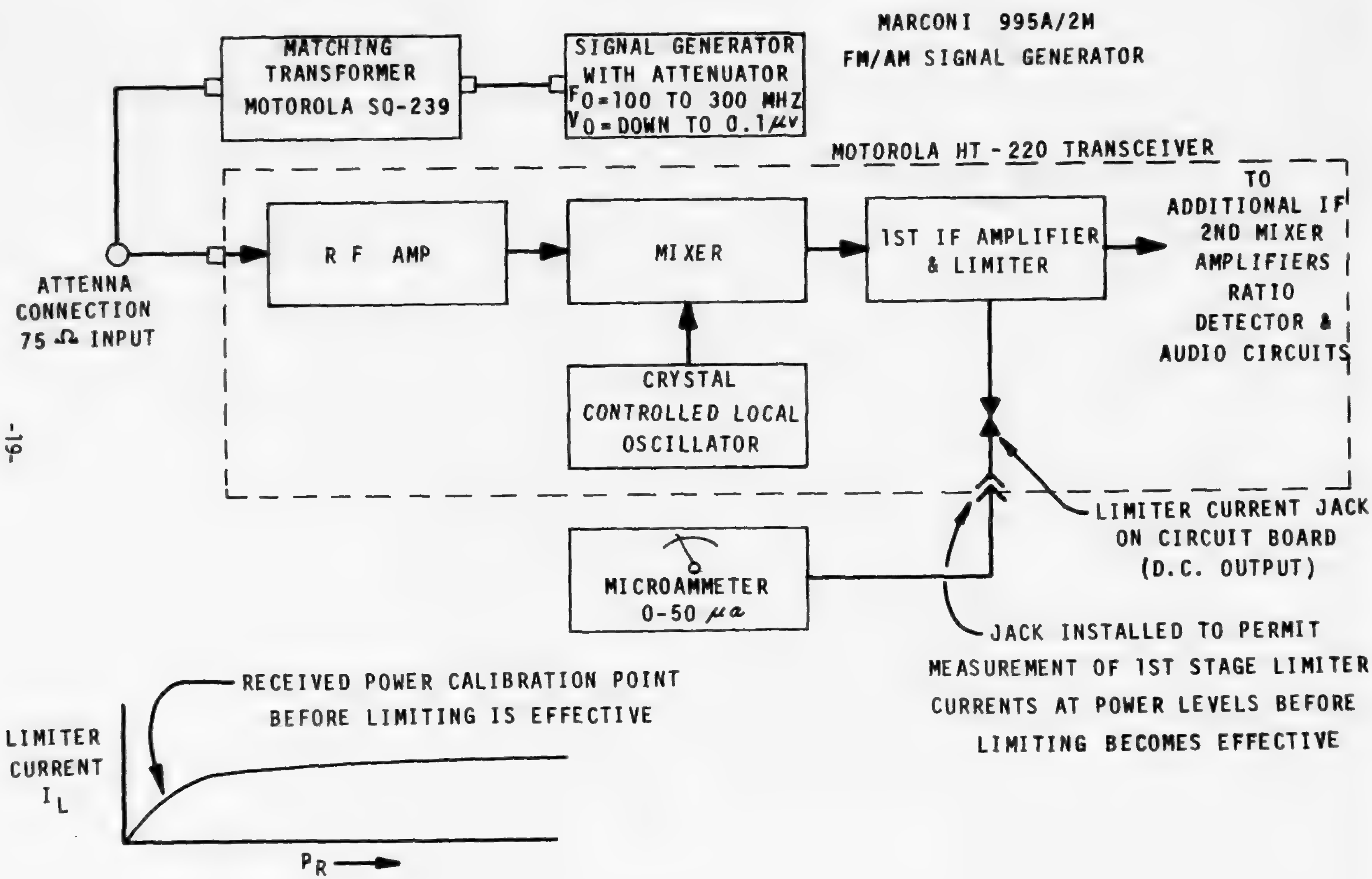

MARCONI 995A/2M
FM/AM SIGNAL GENERATOR
MATCHING TRANSFORMER MOTOROLA SQ-239
SIGNAL GENERATOR WITH ATTENUATOR
F_0=100 TO 300 MHZ
V_0=DOWN TO 0.1μv
MOTOROLA HT-220 TRANSCEIVER
ATTENNA CONNECTION 75 Ω INPUT
R F AMP
MIXER
1ST IF AMPLIFIER & LIMITER
TO ADDITIONAL IF 2ND MIXER AMPLIFIERS RATIO DETECTOR & AUDIO CIRCUITS
CRYSTAL CONTROLLED LOCAL OSCILLATOR
MICROAMMETER 0-50 μa
LIMITER CURRENT JACK ON CIRCUIT BOARD (D.C. OUTPUT)
JACK INSTALLED TO PERMIT MEASUREMENT OF 1ST STAGE LIMITER CURRENTS AT POWER LEVELS BEFORE LIMITING BECOMES EFFECTIVE
RECEIVED POWER CALIBRATION POINT BEFORE LIMITING IS EFFECTIVE
LIMITER CURRENT I_L
P_R

FIG 6

Since the transceivers will be used to make measurements over four frequency channels, some calibrations should be made at the frequency extremes to determine if the calibration is being influenced by frequency. The four frequencies picked for these tests are as follows:

140.025 MHz
140.050 MHz
140.075 MHz
140.125 MHz

Very little frequency influence on the calibrations is expected due to the close proximity of these frequencies.

In addition to a frequency effect on the calibration, the receivers should be checked periodically at least before and after a series of measurements with the readings averaged to obtain final signal power levels.

The microammeter reading can now be calibrated directly in terms of receiver input power with an upper limit determined on the meter where limiting occurs and readings are no longer valid. In using the transceiver to determine signal strength either the transmitter power must be adjusted by a known amount of attenuation or an attenuator inserted between the receiver antenna and the input terminals to bring the signal level within the range of the calibrated readings. Note that this measurement of receiver input power neglects the antenna gain since the measurement is made directly to the receiver input. The antenna gain is taken into account later where it is lumped together with the coupling loss. It should be noted that "antenna gain" has meaning in a reflection free space, but the compartments are far from "free space".

System Test Configuration for One-Way Wireless Measurements

The system test configuration for a one-way wireless system with a base station transceiver hard wired to the Radiax cable is shown in Figure 7.

The HT-220 transceiver is normally designed to feed a 75-Ohm load, therefore, a 75 to 50 Ohm matching transformer (Motorola vehicular antenna adapter SO-239) is needed to match the 75-Ohm transceiver output to the 50-Ohm attenuator input.

A 50-Ohm non-radiating length of cable connects the attenuator to the Radiax cable. A non-radiating section of cable is required to prevent direct pickup from the transceiver to the Radiax, thus invalidating the attenuator measurements when high attenuations (on the order of 50 db or more) are used.

The high Q coaxial choke in series with the HT-220 transceiver and Radiax cable is used to confine the RF radiation to the Radiax cable preventing RF ground currents in surrounding spaces.

Typical test instrumentation and components are as follows:

Matching Transformer	- Motorola SO-239
Power Meter	- H.P. 434A (dc to 12.4 GHz, Power range .01 - 10w)

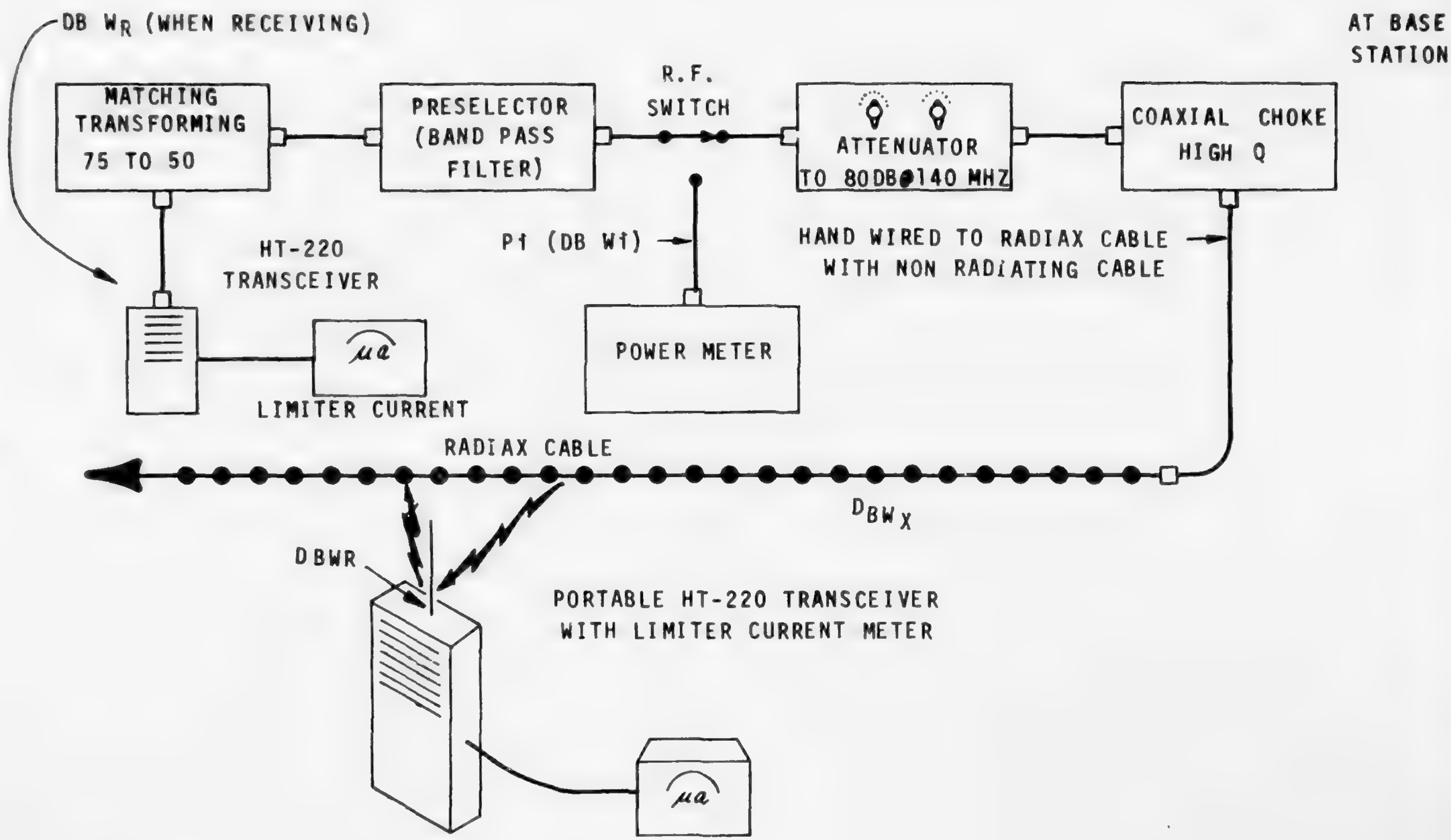

DB W_R (WHEN RECEIVING)
AT BASE STATION
MATCHING TRANSFORMING 75 TO 50
PRESELECTOR (BAND PASS FILTER)
R.F. SWITCH
ATTENUATOR TO 80DB@140 MHZ
COAXIAL CHOKE HIGH Q
HT-220 TRANSCEIVER
Pf (DB Wf)
HAND WIRED TO RADIAX CABLE WITH NON RADIATING CABLE
POWER METER
μa
LIMITER CURRENT
RADIAX CABLE
DBWX
DBWR
PORTABLE HT-220 TRANSCEIVER WITH LIMITER CURRENT METER
μa

FIG 7

Attenuator	-	Kay 432D (dc to 1.0 GHz, 0 to 101 db, 1 W)
Coaxial Choke	-	Andrew Corporation
RF Switch	-	Amphenol type 319

A preselector (bandpass filter) is required to reject shipboard radar frequencies which fall within the detection threshold of the HT-220 receiver. Characteristics of such a filter are discussed in Ref. 1, p. 23-27.

The method of performing a signal strength measurement at any remote location served by the Radiax cable is as follows:

1. Operate base station transmitter into the power meter and record base station power meter reading (dbw_i)

2. Switch transmitter into attenuator and increase attenuation until portable transceiver reports a reading within the limiter current meter calibration range. For receiving reports from the mobile unit the base station operator will require removing all or part of the attenuation. A bypass switch may be installed around the attenuator box for this purpose but care should be used to maintain proper impedance levels when paralleling coaxial cables.

3. Record readings of attenuator and portable transceiver limiter current meter.

The transmitter power dbw_x in the Radiax cable at the portable transceiver location is in terms of dbw

$$dbw_x = dbw_i - db_{atten} - db_{cable\ loss}$$

The coupling loss which includes antenna loss of the transceiver is the difference between the power at the cable dbw_x and the power dbw_R received by the calibrated transceiver, thus

$$\text{Coupling loss} = dbw_x - dbw_R$$

For example:

Suppose P_i = .5 watts (dbw_i = -3dbw)
db_{atten} = 60 db
L = 400 ft. (1.9db/100 ft. x 400 ft = 7.6 db, adding 3.0 db* loss due to power splitter = 10.6 db cable loss)
dbw_R = -140 dbw

Then dbw_x = -3.0dbw - 60.0db - 10.6db = -73.6 dbw (at 400 ft)

Coupling loss = -73.6dbw -(-140dbw) = 66.4 db

The importance of determining coupling loss is that, once known, the system range and safety factors can be easily computed for any power level.

*In this installation a transmission path that long must have gone past the base station and hence, through a power splitter.

This method also has the advantage that antenna gain, transceiver orientation, reflections within the compartment, proximity effect of Radiax to metal surfaces, etc. is all lumped together in one factor called the coupling loss.

Estimates of cable losses from any one compartment to another have been determined in Appendix 1. Thus, coupling loss can be readily computed and recorded together with signal strength readings for any position along the Radiax cable. Power splitter loss is not included in the Appendix 1 tables and must be separately included if the cable path passes through the splitter.

Determination of Coupling Loss in Each Direction

During the one-way wireless signal strength measurements it should be determined whether the coupling loss is reciprocal, i.e., is the coupling loss identical from Radiax to the portable antenna when receiving and from the portable antenna to Radiax when transmitting to the cable?

These measurements are made as follows:

1. Measure the transmitted power dbw_T into the antenna of the portable transceiver by removing the antenna and coupling the transmitter output to the power meter through a 75 to 50-Ohm coupling transformer. Correct for any transformer losses.

2. Measure the power received at the base station from the portable transceiver using a limiter current calibrated HT-220 transceiver coupled directly to the Radiax cable through the matching transformer, preselector and coaxial choke. In other words, the attenuator is set to zero or whatever attenuation is needed to obtain a reading within the limiter current calibration range.

3. Enter the data for both to and from measurements in the table of Figure 8 and compute coupling loss each way taking into account cable loss, power splitter loss, etc.

Figure 8 includes provision for a coupling loss measurement to and from the Radiax cable. In the "portable" column would be recorded the received power and computed coupling loss from Radiax to portable. In the base "station or portable" column would be recorded the base station received power and the coupling loss from the portable antenna to the Radiax cable.

As previously noted, if the receivers are properly calibrated such that a known input power to the receiver terminals gives a reading within the linear portion of the limiter the antenna loss or gain becomes a part of the coupling loss measurement with no loss of accuracy in determining range or signal margins.

The signal strength measurement method described above has the additional advantage of simplicity, ease of implementation and interpretation because:

All the instrumentation with the exception of the portable transceiver and attached meter is contained at the base station where changes in attenuation and all data recording is done.

System Test Configuration for Two-Way Wireless Measurements

For two-way wireless measurements where two portable wireless units communicate with each other, the following measurements should be taken:

1. Measure the transmitted power dbw_T into the antenna of each portable transceiver to be used for the two-way wireless tests by removing the antennas and coupling the transmitter output to the power meter through a 75 to 50-Ohm coupling transformer. Correct for any transformer losses and repeat these measurement periodically.

2. Measure received power dbw_R at each mobile location using the calibrated transceiver limiter current method. Note that these mobile locations must be precisely in the same position, same antenna orientation and same environmental conditions as those encountered during the one-way wireless tests.

3. Using the computed coupling losses in both directions from the one-way wireless measurements, compute the total losses, range and signal margins for the selected locations.

   Note from the above measurements that the total path coupling losses can be computed directly and then compared to the sum of the previously computed coupling losses in either direction.

System Measurement Data and Computation Sheet with Case Examples

A sample form for the taking of signal strength data with a computations format has been prepared (Fig. 8).

It is expected that these forms can be filled out at the base stations with the mobile parties reporting the data.

Three sample cases have been prepared, a one-way wireless test (Fig.9), a two-way wireless test (Fig. 10), and an interference test (Fig. 11).

One-way Measurement Example

The one-way measurement example is for a signal level measurement between the engine control station (hard wired) and the lowest level of the fire room of the forward route.

For purposes of analysis, all the data indicated in the sample sheet should be entered.

Cable length between parties is found from Appendix 1 and can be entered later during the analysis phase. At the base station, the power into the Radiax is obtained from a meter reading and the attenuator box setting is determined after a limiter current reading within the portable transceiver calibration range is determined.

The computations are then performed according to the instructions in the measurement and computation sheet.

Two-Way Measurement Example

The two-way measurement example is for a signal level measurement between two portable transceivers, one located in the F.D. blower room at the same location as the one-way test example and the other located in the fire room. Previous one-way measurements have established a coupling loss of 64 db in the F.D. blower room, and 71 db in the fire room. For generality, the power into each portable antenna (obtained by measurement) is different (-3.0 dbw and 0 dbw).

The total path loss is a cable attenuation + coupling loss of 1.0 db + 64 db + 71 db = 136 db. Thus, the received power at the fire room from the F.D. blower room is -3.0 dbw - 136 db = - 136 dbw and the received power at the F.D. blower room from the fire room is 0 dbw - 136 db = - 136 dbw.

Interference Test Example

An example of an interference signal level measurement is given in Figure 11 for a portable receiver on the first deck in passage 1-83-2-L. Other interference tests at the base station using the Radiax route can be performed by setting the attenuator box to zero and using a limiter current calibrated transceiver to perform a signal level measurement. The power meter is not sensitive enough for this purpose.

Date ____________ Observer ____________ Recorder ____________

<table>
<tr><th colspan="8">SYSTEM MEASUREMENT DATA & COMPUTATION SHEET</th></tr>
<tr><td>Test No.</td><td>One-way</td><td>Two-way</td><td>Interference</td><td colspan="2">Base Station or Portable #</td><td colspan="2">Portable #</td></tr>
<tr><td colspan="4">Route (fwd or aft)</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="4">Compartments -- Name & No.</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="4">Location
within compartments</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="4">Closest Distance
to Radiax, ft.</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="4">Transceiver Orientation for best reception
(Std. orientation is antenna whip vertical
at normal head height.)</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="4">Local Configuration
& Environment</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="4">Transmitter Frequency, MHz</td><td colspan="4"></td></tr>
<tr><td colspan="4">Signal Quality,
Interference, etc.</td><td colspan="4"></td></tr>
<tr><td colspan="4">Cable Length between parties, ft.
& attenuation $dbw_{cable\ loss}$</td><td colspan="4"></td></tr>
<tr><td colspan="4" rowspan="2">Transceiver Pwr to Radiax, dbw_i
Transceiver Pwr to Antenna, dbw_t</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="4" rowspan="2">Attenuator Box Setting, db
dbw_{atten}</td><td>Std.</td><td>Best</td><td>Std.</td><td>Best</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Limiter Current, µA
Received Pwr, dbw_R</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Radiax Cable Pwr, dbw_x
$dbw_x = dbw_i - dbw_{atten} - db_{cable\ loss}$</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Coupling Loss, db
$dbw_x - dbw_R$</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Receiver Sensitivity dbw_{RT}
threshold,</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="4">Range, ft. (from Fig. 5) or
Signal Margin= $dbw_{atten} + dbw_R - dbw_{RT}$
Above Thresholds</td><td colspan="4"></td></tr>
</table>

Figure 8:- System Measurement Data and Computation Sheet
Sample Form

SYSTEM MEASUREMENT DATA & COMPUTATION SHEET		
Test No. — One-way: X; Two-way; Interference	Base Station or Portable	Portable
Route (fwd or aft)	Fwd	Fwd
Compartments -- Name & No.	Engine Control 2-95-0-E	Fire Room 5-79-0-E
Location within compartments	----	Lowest level, midway between boilers, 23' from stbd side
Closest Distance to Radiax, ft.	Hard wired (base station)	$\approx$ 7'
Transceiver Orientation	-----	Antenna horizontal facing port side
Local Configuration & Environment	All doors & hatches closed	All doors and hatches closed;man on station (above catwalk)
Transmitter Frequency, MHz	140.050	
Signal Quality, Interference, etc.	Good signal quality, understanding excellent; occasional noise interference	
Cable Length between parties, ft. & attenuation $dbw_{cable\ loss}$	107', 2.0db + 3.0db(pwr split)=5.0db	
Transceiver Pwr to Radiax, dbw_i	0.5W(-3.0dbw)	---
Transceiver Pwr to Antenna, dbw_t	---	---
Attenuator Box Setting, db dbw_{atten}	70 db	---
Limiter Current, µA Received Pwr, dbw_R	20 µA -142 dbw	20 µA - 142 dbw
Radiax Cable Pwr, dbw_X $dbw_X = dbw_i - dbw_{atten} - db_{cable\ loss}$	---	- 78 dbw_X
Coupling Loss, db $dbw_X - dbw_R$	64 db	64 db
Receiver Sensitivity dbw_{RT} threshold,	-146 dbw for 20 db quieting	-146 dbw For 20 db quieting
Range, ft. (from Fig. 5) or Signal Margin= $dbw_{atten}+dbw_R-dbw_{RT}$ 1. Above Thresholds	70-142-(-146)=74 db above 20 db quieting threshold	

Note 1. For two-way test $dbw_{atten} = 0$.

Figure 9: One-way Wireless Test Sample Data and Calculations

SYSTEM MEASUREMENT DATA & COMPUTATION SHEET

Test No.	One-way	Two-way X	Interference	Base Station or Portable	Portable
Route (fwd or aft)				Fwd	Fwd
Compartments -- Name & No.				F.D.Blower Room 1-79-0-E	Fire Room 5-79-0-E
Location within compartments				At entrance to passage 1-83-2-L	Lowest level; midway between boilers; 23' from stbd side
Closest Distance to Radiax, ft.				2'	≈ 7'
Transceiver Orientation				Antenna vertical; operator facing F.D.blower room	Antenna horizontal; facing port side
Local Configuration & Environment				door to passage 1-54-2-6 closed; door to engine RM closed	all doors and hatches closed; man on station (above catwalk)
Transmitter Frequency, MHz				140.050	
Signal Quality, Interference, etc.				Good signal quality, good understanding, but very susceptible to antenna orientation; ±2 ft. causes fading	
Cable Length between parties, ft. & attenuation $dbw_{cable\ loss}$				43', 0.8 db (assume 1.0 db)	
Transceiver Pwr to Radiax, dbw_i				----	----
Transceiver Pwr to Antenna, dbw_t				0.5w (-3.0dbw)	1.0w (0 dbw)
Attenuator Box Setting, db dbw_{atten}				Note 1.----	Note 1.----
Limiter Current, μA Received Pwr, dbw_R				40 μA -136 dbw	40 μA - 139 dbw
Radiax Cable Pwr, dbw_X $dbw_X = dbw_i - dbw_{atten} - db_{cable\ loss}$				----	----
Coupling Loss, db $dbw_X - dbw_R$				71 db	64 db
Receiver Sensitivity dbw_{RT} threshold,				-146 dbw for 20db quieting	-146 dbw for 20db quieting
Range, ft. (from Fig. 5) or Signal Margin= $dbw_{atten} + dbw_R - dbw_{RT}$ 1. Above Thresholds				+10db above 20db quieting threshold	+7db above 20db quieting threshold

Note 1. For two-way test $dbw_{atten} = 0$

Figure 10: Two-way Wireless Test Sample Data and Calculations

SYSTEM MEASUREMENT DATA & COMPUTATION SHEET		
Test No. — One-way — Two-way — Interference X	Base Station or Portable	Portable
Route (fwd or aft)		Fwd
Compartments -- Name & No.		Passage 1-83-2-L
Location within compartments		At station 95
Closest Distance to Radiax, ft.		≈ 2'
Transceiver Orientation		Antenna vertical
Local Configuration & Environment		door to port passage 1-54-2-L open
Transmitter Frequency, MHz	------	
Signal Quality, Interference, etc.	Low level varying freq. tone observed at rep. rate of about 1 Hz	Low level varying freq. tone observed at rep. rate of about 1 Hz
Cable Length between parties, ft. & attenuation $dbw_{cable\ loss}$	------	
Transceiver Pwr to Radiax, dbw_i		---
Transceiver Pwr to Antenna, dbw_t		----
Attenuator Box Setting, db dbw_{atten}		----
Limiter Current, µA Received Pwr, dbw_R		30 A to >50 A(saturation) -139dbw >-130dbw
Radiax Cable Pwr, dbw_X $dbw_X = dbw_i - dbw_{atten} - db_{cable\ loss}$		----
Coupling Loss, db $dbw_X - dbw_R$		----
Receiver Sensitivity threshold, dbw_{RT}		----
Range, ft. (from Fig. 5) or Signal Margin= $dbw_{atten} + dbw_R - dbw_{RT}$ Above Thresholds	Signal occasionally above receiver 20db threshold by -146-(-139)=+7db to >+16db	Signal occasionally above receiver 20db threshold by -146-(-139)=+7db to >+16db

Figure 11. Test of Interference to Radiax Operation
Sample Data for Portable Transceiver

Test Locations and Procedures

One-way Wireless Tests:- The test locations for obtaining signal strength and interference measurements are given in Tables 3 and 4 for the forward and aft Radiax cable routes and are also indicated by ▽T in the cable installation plan (Appendix 3 and 4). These are considered the minimum number of test locations.

In performing the signal measurements, operators of portable transceivers should get data for a standard whip vertical position and for a "best" orientation, recording the best direction as well as signal strength. The location of the operator should be marked on the deck so that subsequent measurements can be carried out from the same location.

Hatches, emergency escape trunks, etc. should all be closed during these tests, maintaining condition Zebra (watertight integrity) unless required to be open for some special tests.

Table 3: Forward Route One-way Wireless Test Locations (Base Station at Engine Control Room)

Compartment and Number		Location within Compartment	Compartment Doors open	Compartment Doors closed	Test Number
Damage control central 2-54-0-Q	(2)	Center	X		1F-1
Oper.Dept. Office 2-64-2-Q	(1)	Center		X	1F-2
Test laboratory 2-77-1-Q	(1)	Center		X	1F-3
General Workshop 3-54-0-Q		Center		X	1F-4
Electrical Control 3-59-0-C	(2)	Center, between switchboards		X	1F-5
Aux.Mach.Rm.No. 1 3-67-0-E	(2)	Upper level at fwd ladder		X	1F-6
		Upper level extreme port side		X	1F-7
		Lowest level at ladder		X	1F-8
Fire Room 5-79-0-E	(2)	Lowest level between boilers		X	1F-9
		Fire room control station		X	1F-10
		Control Station level at up ladder		X	1F-11
F.D. blower room No. 1 1-79-0-E		Center		X	1F-12
Passage 1-83-2-L		Center of passage	X		1F-13
Passage 1-54-2-L		At frame 79		X	1F-14
	(1)			X	1F-15
F.D. blower room no. 2 1-90-0-E	(1)	Center		X	1F-16
Engine room 5-95-0-E	(2)	Upper level catwalk opposite LP turbine		X	1F-17
F.D.Storeroom 3-107-1-A		Upper level at ladder		X	1F-18
Shaft Alley #1 4-107-0-0	(2)	At bottom of ladder	X		1F-19

(1) Test for radiation levels in unwired compartments or passages
(2) Locations for two-way wireless tests prior to and after Radiax installation

Table 4: Aft Route One-way Wireless Test Locations
(Base Station at Repair III)

Compartment and Number	Location within Compartment	Compartment Doors open	Compartment Doors closed	Test Number
Passage (main deck) 1-121-0-L (2)	Opposite post office		X	1A-1
Passage (main deck) 1-95-4-L (1)	Fwd of bulkhead 107		X	1A-2
Aux. Radio Room 1-110-2-0 (1)	Center		X	1A-3
Passage (2nd deck) 2-121-0-L	Opposite scullery	X		1A-4
CPO Quarters 2-127-0-L	Center		X	1A-5
Galley 2-107-0-L	Center	X		1A-6
Crew's Mess 2-107-0-L (2)	At down ladder	X		1A-7
Passage (2nd deck) 2-132-0-L	Midway		X	1A-8
Laundry 2-136-0-Q	Center		X	1A-9
Torpedo Room 2-147-0-M (2)	Center between Sta 147 & 158;also, near stern		X X	1A-10 1A-11
VDS Mach. Room 2-158-0-E	Near door to torpedo room		X	1A-12
Passage 3-155-1-L	Bottom of ladder	X		1A-13
Steering Room 3-155-0-E (2)	At control station fwd	X		1A-14
Passage 3-155-0-E	Center	X		1A-15
Passage 3-147-01-L	Center		X	1A-16
Aux.Mach. Rm. #2 SWBD Area 3-133-01-E (2)	Center		X	1A-17
Aux.Mach. Rm. #2 Diesel Area 3-132-01-E	At fwd end		X	1A-18
Crew Living Space 3-121-0-L	Center Aft-stbd corner	X X		1A-19 1A-20
Shaft Alley No. 2 5-121-0-Q	Bottom of ladder	X		1A-21
Passage 3-110-2-L	At down ladder		X	1A-22

(1) Test for radiation levels in unwired compartments or passages.
(2) Locations for two-way wireless tests prior to and after Radiax installation.

Table 4 (cont'd)

Compartment and Number	Location within Compartment	Compartment Doors open	Compartment Doors closed	Test Number
Passage 5-111-2-L	Midway		X	1A-23
Shaft Alley No. 1 4-107-0-Q (2)	At bottom of ladder	X		1A-24

Two-way Wireless Tests:- Two-way wireless measurements should be made between the selected locations given in Tables 5 and 6 where coupling loss measurements between the cable and a portable transceiver will have been determined by one-way wireless tests between base stations and portable transceivers.

For the pre-Radiax two-way measurements (Appendix 2) Tables 5 and 6 define the compartment locations while Tables 3 and 4 give additional details on location within compartments. The pre-Radiax tests should be recorded on the form of Figure 9, entering all the pertinent information except that from these tests only the total two-way coupling loss can be determined.

Table 5:- Two-way Wireless Test Locations
Forward Route

Transceiver No. 1 Compartment and Number	Transceiver No. 2 Compartment and Number	Test Number
Damage Control Central 2-54-0-Q	Electrical Central 3-59-0-C	2F-1
Damage Control Central 2-54-0-Q	Aux.Mach.Rm.No. 1 3-67-0-E	2F-2
Damage Control Central 2-54-0-Q	Fire Rm.Control Station 5-79-0-E	2F-3
Damage Control Central 2-54-0-Q	Engine Rm.Control Station 5-95-0-E	2F-4
Damage Control Central 2-54-0-Q	Shaft Alley No. 1 4-107-0-0	2F-5
Engine Rm.Control Sta. 5-95-0-E	Fire Rm.Control Station 5-79-0-E	2F-6
Engine Rm.Control Sta. 5-95-0-E	Electrical Central 3-59-0-C	2F-7
Engine Rm.Control Sta. 5-95-0-E	Aux.Mach.Rm. No. 1 3-67-0-E	2F-8
Engine Rm.Control Sta. 5-95-0-E	Shaft Alley No. 1 4-107-0-0	2F-9
Engine Rm.Control Sta. 5-95-0-E	Repair III 2-141-2-A	2F-10

NOTE: For exact locations within compartments see Table 3, note (2).

Table 6:- Two-way Wireless Test Locations
(Aft Route)

Transceiver No. 1 Compartment and Number	Transceiver No. 2 Compartment and Number	Test Number
Repair III 2-141-2-A	Passage (main deck) 7-121-0-L	2A-1
Repair III 2-141-2-A	Torpedo Room 2-147-0-M	2A-2
Repair III 2-141-2-A	Aux.Mach. Room No. 2 3-132-01-E	2A-3
Repair III 2-141-2-A	Shaft Alley No. 1 5-121-0-Q	2A-4
Repair III 2-141-2-A	Steering Room 3-155-0-E	2A-5
Repair III 2-141-2-A	Crew's Mess 2-107-0-L	2A-6
Aux.Mach.Rm. No. 2 3-132-01-E	Shaft Alley No. 1 4-107-0-Q	2A-7
Aux.Mach.Rm. No. 2 3-132-01-E	Steering Room 3-155-0-E	2A-8

NOTE: For exact locations within compartments see Table 3, note (2).

Interference Measurements:- Interference measurements should be made to establish the signals from Radiax in those compartments not wired with Radiax. Both quantitative and qualitative measurements can be obtained using the standard data sheets with measurement data supplied from calibrated transceivers. Generally, the need for such measurements below the main deck is unnecessary since the object of the communications system is to radiate energy wherever possible. On the main deck and above it is necessary to both contain the emissions within the ship and keep them out of certain compartments (such as the communications room). Tables 3 and 4 (note 1) indicate those compartments not wired with Radiax that should be tested for signal level when the Radiax system is in use.

Interference of other systems to Radiax whether portable units or at base stations must be determined by isolating interfering sources one at a time. Thus, radars and communications systems that have been analyzed to be potential sources of interference should be turned on and off while measurements are taken in various locations.

The RF interference induced by the two-way units into ships cabling is expected to be virtually nonexistent since all of the ships cabling is enclosed by a heavy metal shield (armor). As previously discussed, the large frequency difference between dc or 60 Hz control circuits and 140 MHz in the wireless communications system essentially eliminates the Radiax interference problem to control circuits. For control circuits located within compartments covered

by Radiax or in base stations, the RF signal pickup should be in the very low millivolt range at worst, well below other types of pickup from 60 Hz radar, sonar and high powered communication systems.

An FM transceiver system is ideally suited in this application because of the extremely effective suppression of AM-type noise which is very prevalent everywhere in the ship due to operation of switches, motors, relays, etc. In addition, there is a noise quieting gain common to FM systems once the signal is above the detection threshold. This quieting gain increases the output signal-to-noise ratio relative to an AM system by an estimated 10 db after the input signal-to-noise ratio exceeds about 10 db for this almost narrow band FM system.

The interference of Radiax communications using the HT-220 transceivers to other ship communications systems aboard the DE-1052 class destroyer escort was investigated and reported in reference 1. It was determined in that study that the HT-220 could interfere with the receiver portion of the PRC-73 and with the URR-27 receiver. In addition, it was found that a preselector would be needed to be hard wired to the Radiax cable to reduce the transceiver spurious responses to high-level, out-of-band emissions from the SPS-37 and SPS-40 radars.

The table below is reproduced from reference 1, showing that harmonic frequencies of the HT-220 up to $7F_o$ should be measured. It is recommended that field intensity measurements be made to obtain the data for Table 7, using an Empire field strength meter in the communications room and aux. radio room.

Ref. 1. Mattox, W.J., "Electromagnetic Compatibility Study of a Wireless Intercommunication System for DE-1052 Class," ITT Research Institute, Electromagnetic Compatibility Analysis Center, Annapolis, Md., July 1974

Table 7.

EMISSION DATA RECORDING SHEET

Equipment Under Test ______________ Date ____________________

S/N ______________ Test Personnel ____________________

Antennas ______________ ____________________

______________ Test Location ____________________

Measurement Equipment ______________ ____________________

______________ Position on Radiax ____________________

______________ ____________________

Frequency MHz	Position From Vertical Horizontal	Meter Reading dB/uV	Attn Factor dB	Ant Factor dB	Other Factors dB	Corrected Level dB/uV/M	Notes
____(F_o)							
____(4/3 F_o)							
____(5/3 F_o)							
____(2 F_o)							
____(7/3 F_o)							
____(8/3 F_o)							
____(3 F_o)							
____(10/3 F_o)							
____(11/3 F_o)							
____(4 F_o)							
____(13/3 F_o)							
____(14/3 F_o)							
____(5 F_o)							
____(16/3 F_o)							
____(17/3 F_o)							
____(6 F_o)							
____(19/3 F_o)							
____(20/3 F_o)							
____(7 F_o)							

Ref. 1. Mattox, W.J., "Electromagnetic Compatibility Study of a Wireless Intercommunication System for DE-1052 Class," ITT Research Institute, Electromagnetic Compatibility Analysis Center, Annapolis, Md., July 1974

APPENDIX 1

INTERCOMPARTMENT CABLE LENGTHS (feet)
(Center to Center of Each Compartment)

and

CABLE ATTENUATION LOSSES (db)

For Two Radiax Cable Routes

On DE-1094 Destroyer Escort

ROUTE #1 (Aft)

Note: () = Loss in db computed as 1.9 db/100 ft.

	Passage 1-121-0-L	Crews Mess	Galley	CPO Lounge	CPO Quarters	Passage 2-121-0-L	Passage 2-132-0-L	Repair #3	Laundry	CG Locker 2-146-1	Torpedo Room	Passage 3-155-1-L	Steering Room	Passage 3-155-2-L	WR Storeroom 3-152-2-A	Passage 3-147-01-L	Trunk Room 3-148-2-A	Aux. Mach. Room #2 (Switchboard)	Compressor Area	Diesel Area	Crew Living Space	WT Trunk 3-121-2T	Shaft Alley No. 2 5-121-0-Q	Repair Parts Storeroom 3-107-1-A	Passage 3-110-2-L	Passage 5-111-2-L	Ref. Mach. Room	Shaft Alley No. 1
Passage 1-121-0-L	--																											
Crews Mess 2-107-0-L	59 (1.1)	--																										
Galley	100 (1.9)	41 (0.8)	--																									
CPO Lounge	126 (2.4)	67 (1.3)	26 (1.5)	--																								
CPO Quarters	144 (2.7)	85 (1.6)	44 (0.8)	18 (0.3)	--																							
Passage 2-121-0-L	159 (3.0)	100 (1.9)	59 (1.1)	33 (0.6)	15 (0.3)	--																						
Passage 2-132-0-L	178 (3.4)	119 (2.3)	78 (1.5)	52 (1.0)	34 (0.7)	19 (0.4)	--																					
Repair #3	206 (3.9)	147 (2.8)	106 (2.0)	80 (1.5)	62 (1.2)	47 (0.9)	28 (0.5)	--																				
Laundry	240 (4.6)	181 (3.4)	140 (2.7)	114 (2.2)	96 (1.8)	81 (1.5)	62 (1.2)	34 (0.7)	--																			
CG Locker 2-146-1	250 (4.8)	191 (3.6)	150 (2.9)	124 (2.4)	106 (2.0)	91 (1.7)	72 (1.4)	44 (0.8)	10 (0.2)	--																		
Torpedo Room	288 (5.5)	229 (4.4)	188 (3.6)	162 (3.1)	144 (2.7)	129 (2.5)	110 (2.1)	82 (1.6)	48 (0.9)	38 (0.7)	--																	
Passage 3-155-1-L 3-155-1-L	323 (6.1)	264 (5.0)	223 (4.2)	197 (3.7)	179 (3.4)	169 (3.2)	145 (2.8)	117 (2.2)	83 (1.6)	73 (1.4)	35 (0.7)	--																
Steering Room	341 (6.5)	282 (5.4)	241 (4.6)	215 (4.1)	197 (3.7)	182 (3.5)	163 (3.1)	135 (2.6)	101 (1.9)	91 (1.7)	53 (1.0)	18 (0.3)	--															
Passage 3-155-2-L 3-155-2-L	351 (6.7)	292 (5.6)	251 (4.8)	225 (4.3)	207 (3.9)	192 (3.7)	173 (3.3)	145 (2.8)	111 (2.1)	101 (1.9)	63 (1.2)	28 (0.5)	10 (0.2)	--														
WR Storeroom 3-152-2-A	356 (6.8)	297 (5.6)	256 (4.9)	230 (4.4)	212 (4.0)	197 (3.7)	178 (3.4)	150 (2.9)	116 (2.2)	106 (2.0)	68 (1.3)	33 (0.6)	15 (0.3)	5 (0.1)	--													
Passage 3-147-01-L	362 (6.9)	303 (5.8)	262 (5.0)	236 (4.5)	218 (4.1)	203 (3.9)	184 (3.5)	156 (3.0)	122 (2.3)	112 (2.1)	74 (1.4)	39 (0.7)	21 (0.4)	11 (0.2)	6 (0.1)	--												
Trunk Room 3-148-2-A	369 (7.0)	310 (5.9)	269 (5.1)	243 (4.6)	225 (4.3)	210 (4.0)	191 (3.6)	163 (3.1)	129 (2.5)	119 (2.3)	81 (1.5)	46 (0.9)	28 (0.5)	18 (0.3)	13 (0.3)	7 (0.1)	--											
Aux. Mach. Room #2 (Switchboard)	3-1 (7.2)	322 (6.1)	281 (5.3)	255 (4.9)	237 (4.5)	222 (4.2)	203 (3.9)	175 (3.3)	141 (2.7)	131 (2.5)	93 (1.8)	58 (1.1)	40 (0.8)	30 (0.6)	25 (0.5)	19 (0.4)	12 (0.2)	--										
Compressor Area	391 (7.4)	332 (6.3)	291 (5.5)	265 (5.0)	247 (4.7)	232 (4.4)	213 (4.1)	185 (3.5)	151 (2.9)	141 (2.7)	103 (2.0)	68 (1.3)	50 (1.0)	40 (0.8)	35 (0.7)	29 (0.6)	22 (0.4)	10 (0.2)	--									
Diesel Area	409 (7.8)	350 (6.7)	309 (5.9)	283 (5.4)	265 (5.0)	250 (4.8)	231 (4.4)	203 (3.9)	169 (3.2)	159 (3.0)	121 (2.3)	86 (1.6)	68 (1.3)	58 (1.1)	53 (1.0)	47 (0.9)	40 (0.8)	28 (0.5)	18 (0.3)	--								
Crew Living Space	449 (8.5)	390 (7.4)	349 (6.6)	323 (6.1)	305 (5.8)	290 (5.5)	271 (5.2)	243 (4.6)	209 (4.0)	199 (3.8)	161 (3.1)	126 (2.4)	108 (2.1)	98 (1.9)	93 (1.8)	87 (1.7)	80 (1.5)	68 (1.3)	58 (1.1)	40 (0.8)	--							
WT Trunk 3-121-2T	470 (8.9)	411 (7.8)	370 (7.0)	344 (6.5)	316 (6.0)	311 (5.9)	292 (5.6)	264 (5.0)	230 (4.4)	220 (4.2)	182 (3.5)	147 (2.8)	129 (2.5)	119 (2.3)	114 (2.2)	108 (2.1)	101 (1.9)	89 (1.7)	79 (1.5)	61 (1.2)	21 (0.4)	--						
Shaft Alley No. 2 5-121-0-Q	482 (9.2)	423 (8.0)	382 (7.3)	356 (6.8)	334 (6.4)	323 (6.1)	304 (5.8)	276 (5.2)	242 (4.6)	232 (4.4)	194 (3.7)	159 (3.0)	141 (2.7)	131 (2.5)	126 (2.4)	120 (2.3)	113 (2.2)	101 (1.9)	91 (1.7)	73 (1.4)	33 (0.6)	12 (0.2)	--					
Repair Parts Storeroom 3-107-1-A	497 (9.4)	438 (8.3)	397 (7.5)	371 (7.1)	353 (6.7)	338 (6.4)	319 (6.1)	291 (5.5)	257 (4.9)	247 (4.7)	209 (4.0)	174 (3.3)	156 (3.0)	146 (2.8)	141 (2.7)	135 (2.6)	128 (2.4)	116 (2.2)	106 (2.0)	88 (1.7)	48 (1.4)	27 (0.5)	15 (0.3)	--				
Passage 3-110-2-L	508 (9.7)	449 (8.5)	408 (7.8)	382 (7.3)	364 (6.9)	349 (6.6)	330 (6.3)	302 (5.7)	268 (5.1)	258 (4.9)	220 (4.2)	185 (3.5)	167 (3.2)	157 (3.0)	152 (2.9)	146 (2.8)	139 (2.6)	127 (2.4)	117 (2.2)	99 (1.9)	59 (1.1)	38 (0.7)	26 (0.5)	11 (0.2)	--			
Passage 5-111-2-L	530 (10.1)	471 (9.0)	430 (8.2)	404 (7.7)	386 (7.3)	371 (7.1)	352 (6.7)	324 (6.2)	290 (5.5)	280 (5.3)	242 (4.6)	207 (3.9)	189 (3.6)	179 (3.4)	174 (3.3)	168 (3.2)	161 (3.1)	149 (2.8)	139 (2.6)	121 (2.3)	81 (1.5)	60 (1.1)	48 (0.9)	33 (0.6)	22 (0.4)	--		
Ref. Mach. Room	545 (10.4)	486 (9.2)	445 (8.5)	419 (8.0)	401 (7.6)	386 (7.3)	367 (7.0)	339 (6.4)	305 (..8)	295 (5.6)	257 (4.9)	222 (4.2)	204 (3.9)	194 (3.7)	189 (3.6)	183 (3.5)	176 (3.3)	164 (3.1)	154 (2.9)	136 (2.6)	96 (1.8)	75 (1.4)	63 (1.2)	45 (0.9)	37 (0.7)	15 (0.3)	--	
Shaft Alley No. 1	572 (10.9)	513 (9.8)	472 (9.0)	446 (8.5)	428 (8.1)	413 (7.9)	394 (7.5)	366 (7.0)	332 (6.3)	322 (6.1)	284 (5.4)	249 (4.7)	231 (4.4)	221 (4.2)	216 (4.1)	210 (4.0)	203 (3.9)	191 (3.6)	181 (3.4)	163 (3.1)	123 (2.3)	102 (1.9)	90 (1.7)	75 (1.5)	64 (1.2)	42 (0.8)	27 (0.5)	--

ROUTE #2 (Fwd)

Note: ()=Loss in db computed as 1.9db/100 ft.

	Damage Control Central	General Workshop 3-54-0-Q	Crew Living Space 3-59-2-L	Electrical Central	Aux. Mach. Room #1	Fire Room	F.D.Blower Room #1 1-79-0-E	Passage 1-83-2-L	Comm. Officer Sr. 1-95-2-L	Engine Control 2-95-0-E	Repair Parts Storeroom 3-107-1-A	Shaft Alley No. 1
Damage Control Central	--											
General Workshop 3-54-0-Q	22 (0.4)	--										
Crew Living Space 3-59-2-L	44 (0.8)	22 (0.4)	--									
Electrical Central	68 (1.3)	46 (0.9)	24 (0.5)	--								
Aux. Mach. Room #1	124 (2.4)	102 (1.9)	80 (1.5)	56 (1.1)	--							
Fire Room	232 (4.4)	210 (4.0)	188 (3.6)	164 (3.1)	108 (2.1)	--						
F.D.Blower Room #1 1-79-0-E	275 (5.3)	253 (4.8)	231 (4.4)	207 (3.9)	151 (2.9)	43 (0.8)	--					
Passage 1-83-2-L	286 (5.4)	264 (5.0)	242 (4.6)	218 (4.1)	162 (3.1)	54 (1.0)	11 (0.2)	--				
Comm. Officer Sr. 1-95-2-L	319 (6.1)	297 (5.6)	275 (5.2)	251 (4.8)	195 (3.7)	87 (1.7)	44 (0.8)	33 (0.6)	--			
Engine Control 2-95-0-E	339 (6.4)	317 (6.0)	295 (5.6)	271 (5.2)	215 (4.1)	107 (2.0)	64 (1.2)	53 (1.0)	20 (0.4)	--		
Repair Parts Storeroom 3-107-1-A	392 (7.5)	370 (7.0)	348 (6.6)	324 (6.2)	268 (5.1)	160 (3.0)	117 (2.2)	106 (2.0)	73 (1.4)	53 (1.0)	--	
Shaft Alley No. 1	419 (8.0)	397 (7.5)	375 (7.1)	351 (6.7)	295 (5.6)	187 (3.6)	144 (2.7)	133 (2.5)	100 (1.9)	80 (1.5)	27 (0.5)	--

APPENDIX 2

Shipboard Communications Measurements Prior to Radiax Cable Installation

Several past experiments with portable FM low power transceviers aboard Navy ships by NAVSEC and NSRDC personnel have established that it is possible to communicate across several closed steel compartments. Apparently, the electromagnetic radiation follows ships cables, piping, ducting and other penetrations to provide some leakage radiation between steel compartments. The unpredictable nature of this leakage radiation, limited coverage and great susceptibility to changes in local environment makes it impractical to rely totally on such a low reliability transmission path. The installation of Radiax cable will significantly increase the radiation throughout the wired compartments, in effect greatly augmenting the normal leakage transmission paths.

To evaluate the contribution of the Radiax cable in providing radiation within compartments, it is necessary to establish some baseline of performance without Radiax since both normal leakage radiation together with Radiax radiation will exist once the Radiax is installed. Thereafter, separation of the two components is impossible. Thus, it is necessary to establish received signal strengths across several compartments prior to Radiax installation.

The signal strength measurement method using calibrated transceivers discussed in the test plan should be used (Fig. 6) using the same procedures as discussed under the section "System Test Configuration for Two-way Wireless Measurements". The locations for these pre-Radiax tests are shown in Tables 5 and 6 and subsequent tests (both one-way and two-way) must be performed in the identical locations duplicating all conditions as closely as possible.

<u>Hard Wiring Two Base Stations to Radiax Cable</u>

Under the present plan only one transceiver is hard wired to the Radiax cable at a base station. Two transceivers cannot be hard wired to the same Radiax cable (say, at the engineering control station and damage control central) because the transmitter output power will destroy the receiver input circuit at the other end. In other words, with several hundred feet of Radiax cable, the cable losses are insufficient to absorb the transmitted power, leaving an excessive amount of power to be dissipated at the receiver input. For example, with no line loss, the voltage at the receiver input for 1 watt of transmitted power across 50 ohms would be from $P = v^2/R$; $v = \sqrt{1 \times 50} = 7.1$ volts RMS.

The Motorola HT-220 transceivers have several protection features which protect the receiver input from excessive input voltages through radiation pickup when transmitting. The RF amplifier input has a diode limiter, during transmission the supply voltage to the receiver RF, mixer and IF stages are

removed and the common antenna is switched from the receiver input to transmitter output. These features protect against radiation into the sensitive receiver input stage.

For a hard wired transceiver these protection features would be of no value since the receiver would be coupled to the Radiax with receiver power circuits active and sufficient power coming through the Radiax to burn out the diode limiter. (Information supplied by manufacturer.)

If a scheme for employing two hard wired transceivers on a common Radiax cable is desired, then the receivers should be modified to provide greater protection in the receive mode.

During the tests where the two cable routes are tied together in the shaft alley, care must be taken that one of the hard wired base stations is removed from the Radiax cable, otherwise damage to both transceivers is likely.

APPENDIX 3

Aft Radiax Route

Base Station at Repair No. 3

SIGNIFICANCE OF SYMBOLS

DECK PENETRATION OF STUFFING TUBE

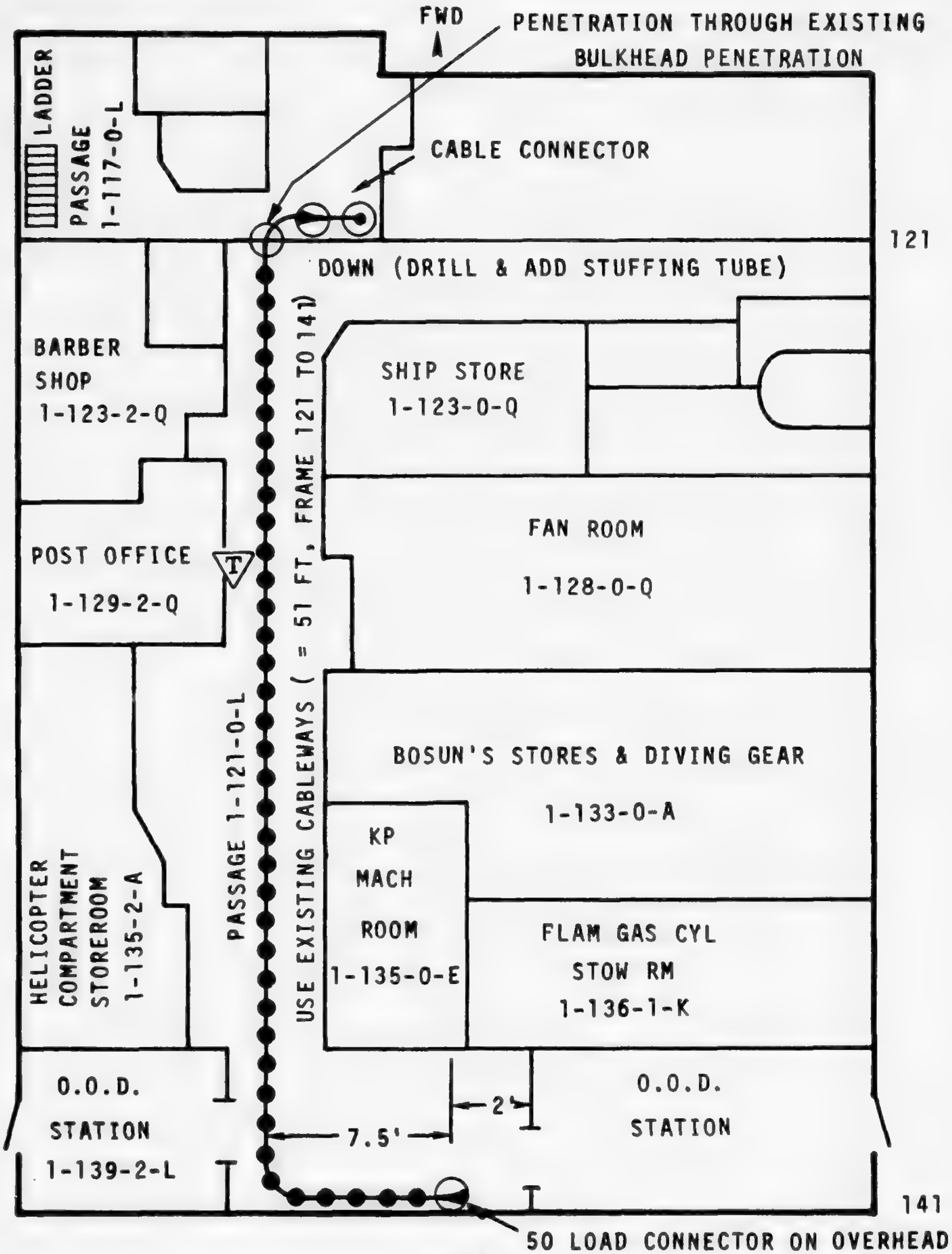
BULKHEAD PENETRATION OR STUFFING TUBE

MULTICABLE TRANSIT FRAME

TRANSCIEVER LOCATION DURING TEST

CONNECTOR

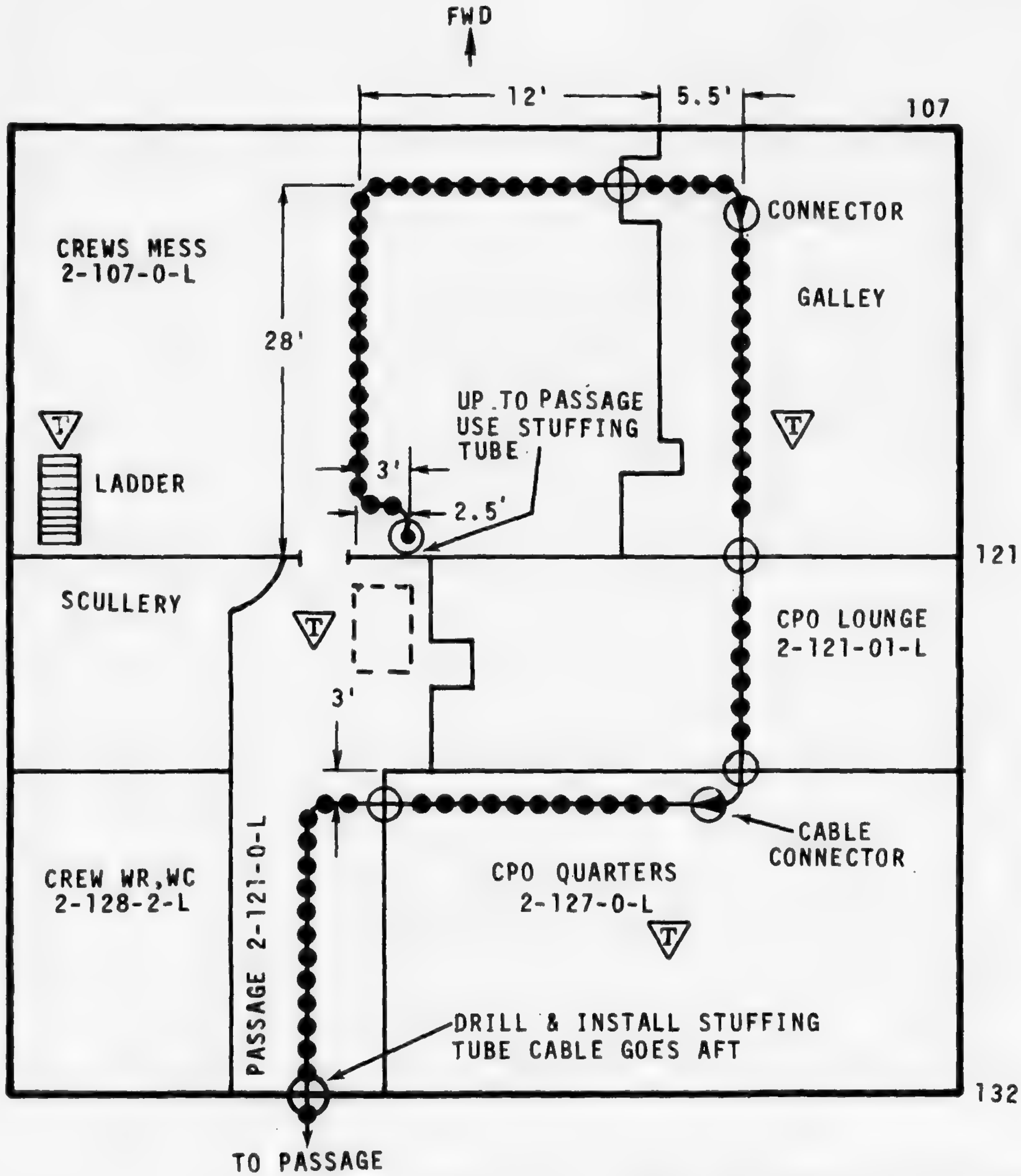
FEMALE MALE



NOTE: APPROX CABLE LENGTH ON THIS FIGURE (INCLUDING VERTICALS) = 72 FT.

NOTE: DURING PORTIONS OF THE TEST THE ENTIRE PASSAGEWAY LENGTH OF RADIAX WILL BE DISCONNECTED AT THE CONNECTOR SYSTEM AND TERMINATED WITH A 50 OHM LOAD.

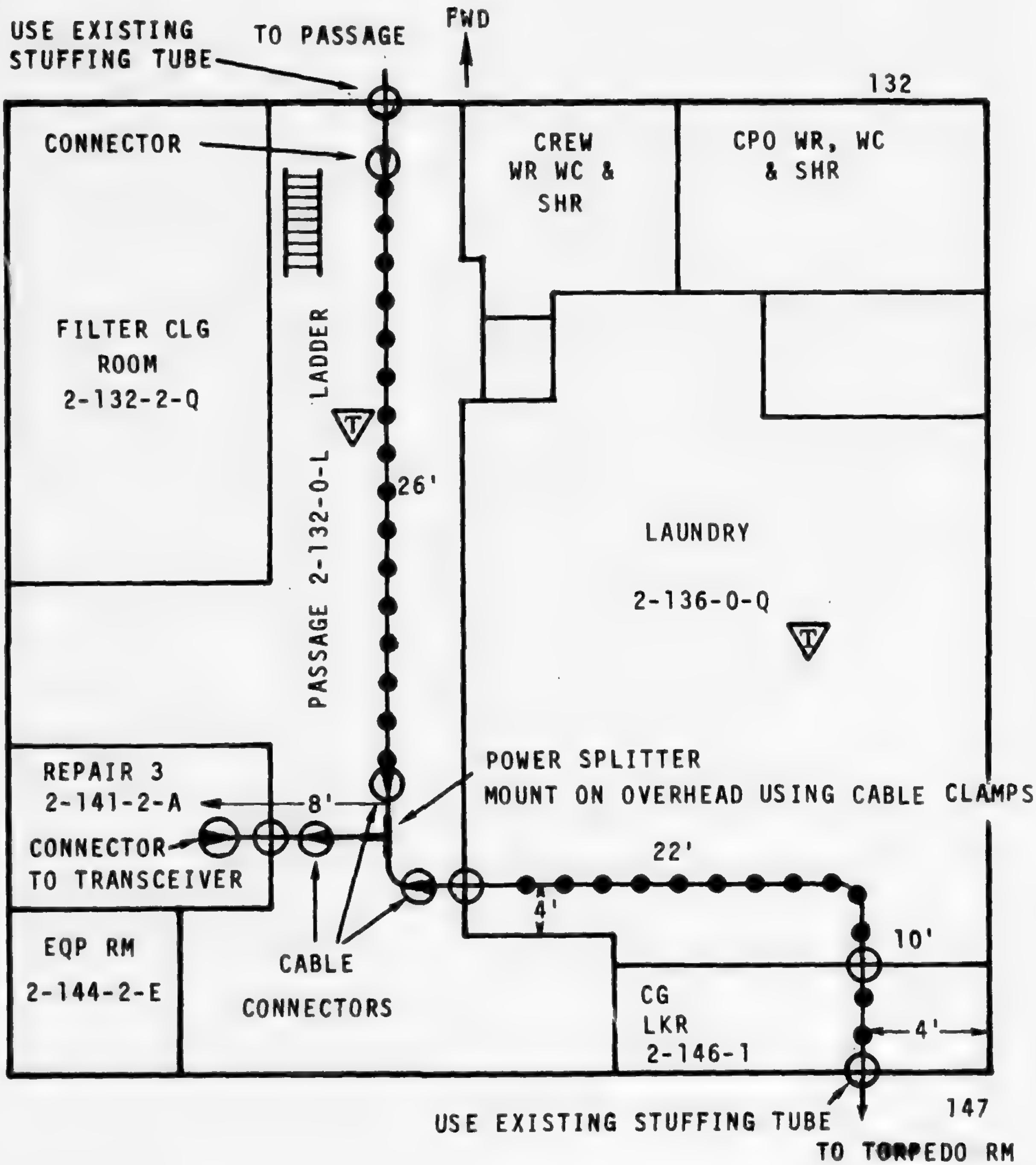
FIG 3-1



NOTE: USE EXISTING CABLEWAYS AND BULKHEAD PENETRATIONS THROUGHOUT

NOTE: APPROX CABLE LENGTH ON THIS FIG = 125

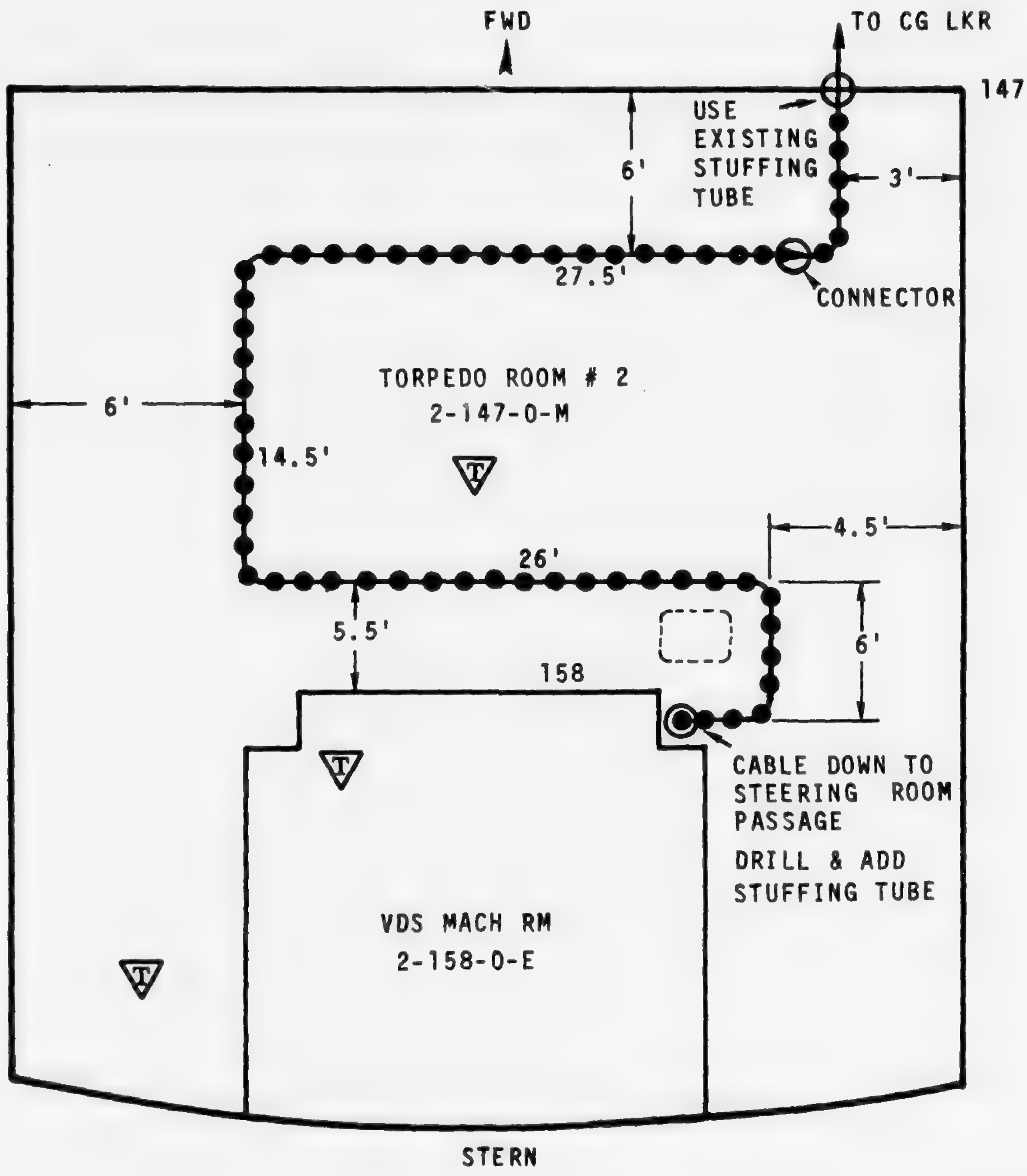
FIG 3-2



NOTE: USE EXISTING CABLEWAYS AND BULKHEAD PENETRATIONS

NOTE: APPROX CABLE LENGTH ON THIS FIG. ≈ 66 FT.

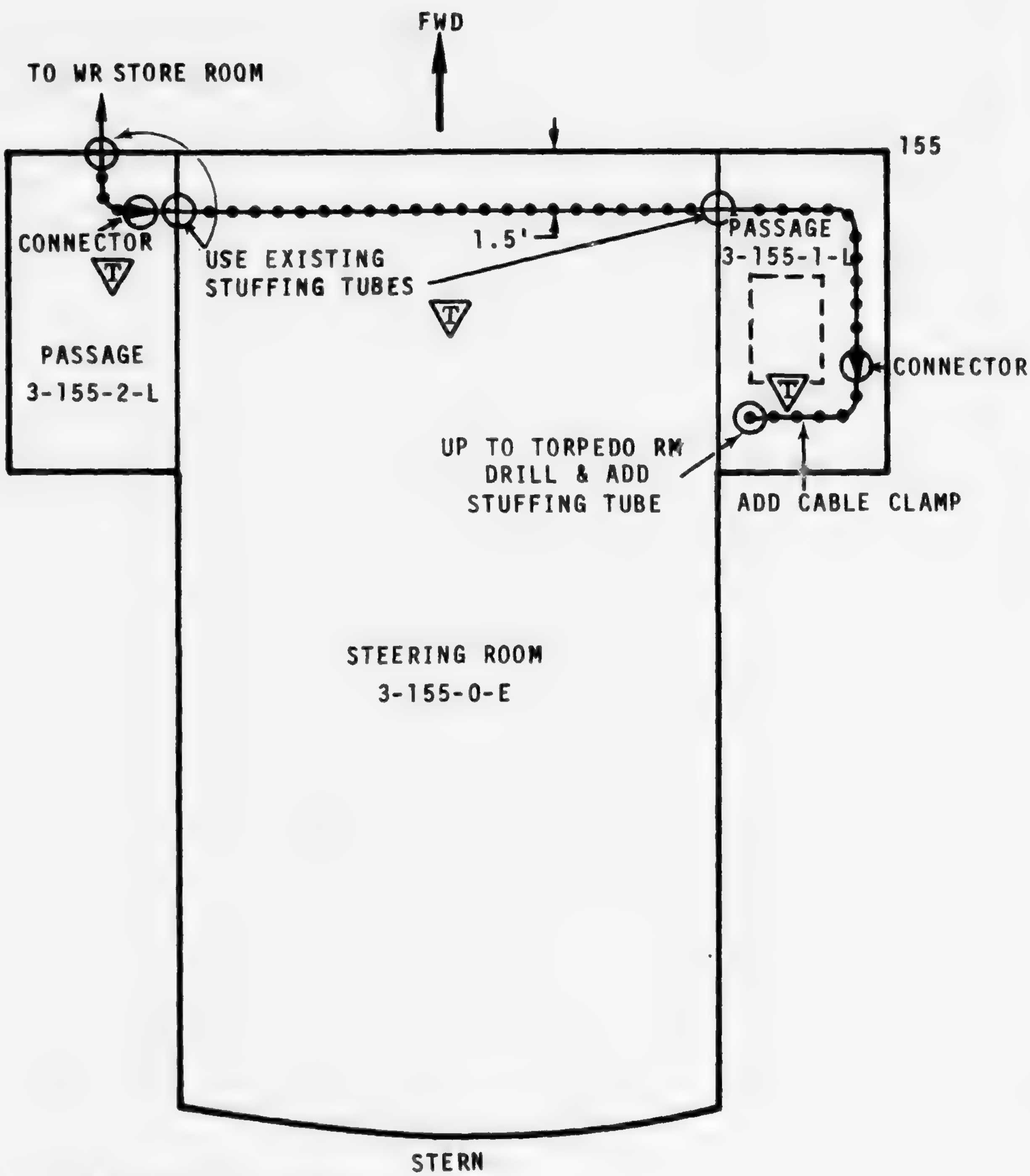
FIG 3-3



NOTE: USE EXISTING CABLEWAYS

NOTE: APPROX CABLE LENGTH ON THIS FIG = 84 FT

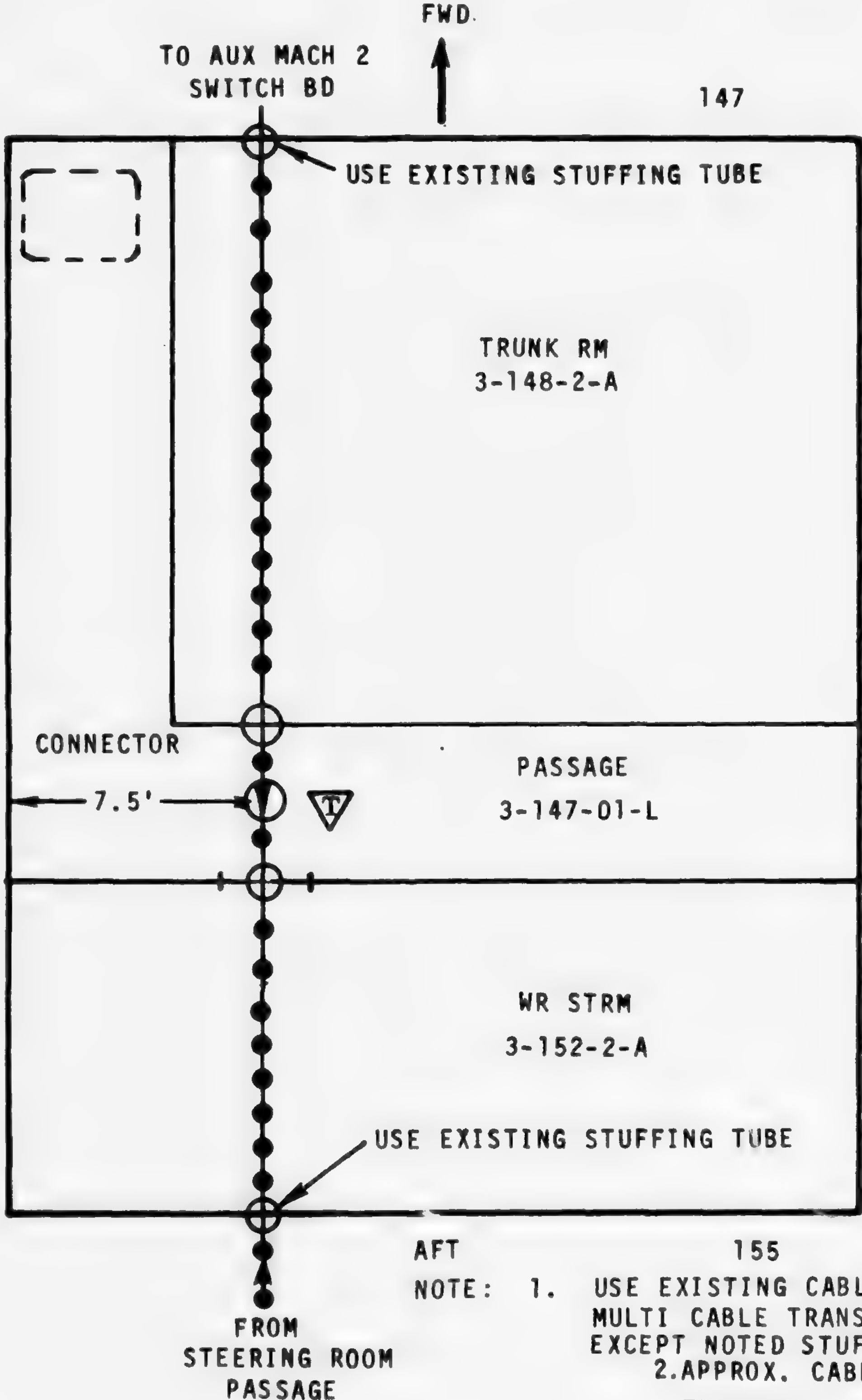
FIG 3-4



NOTE: USE EXISTING CABLEWAYS

NOTE: APPROX CABLE LENGTH THIS FIG (INCLUDING VERTICALS) ≈ 46 FT.

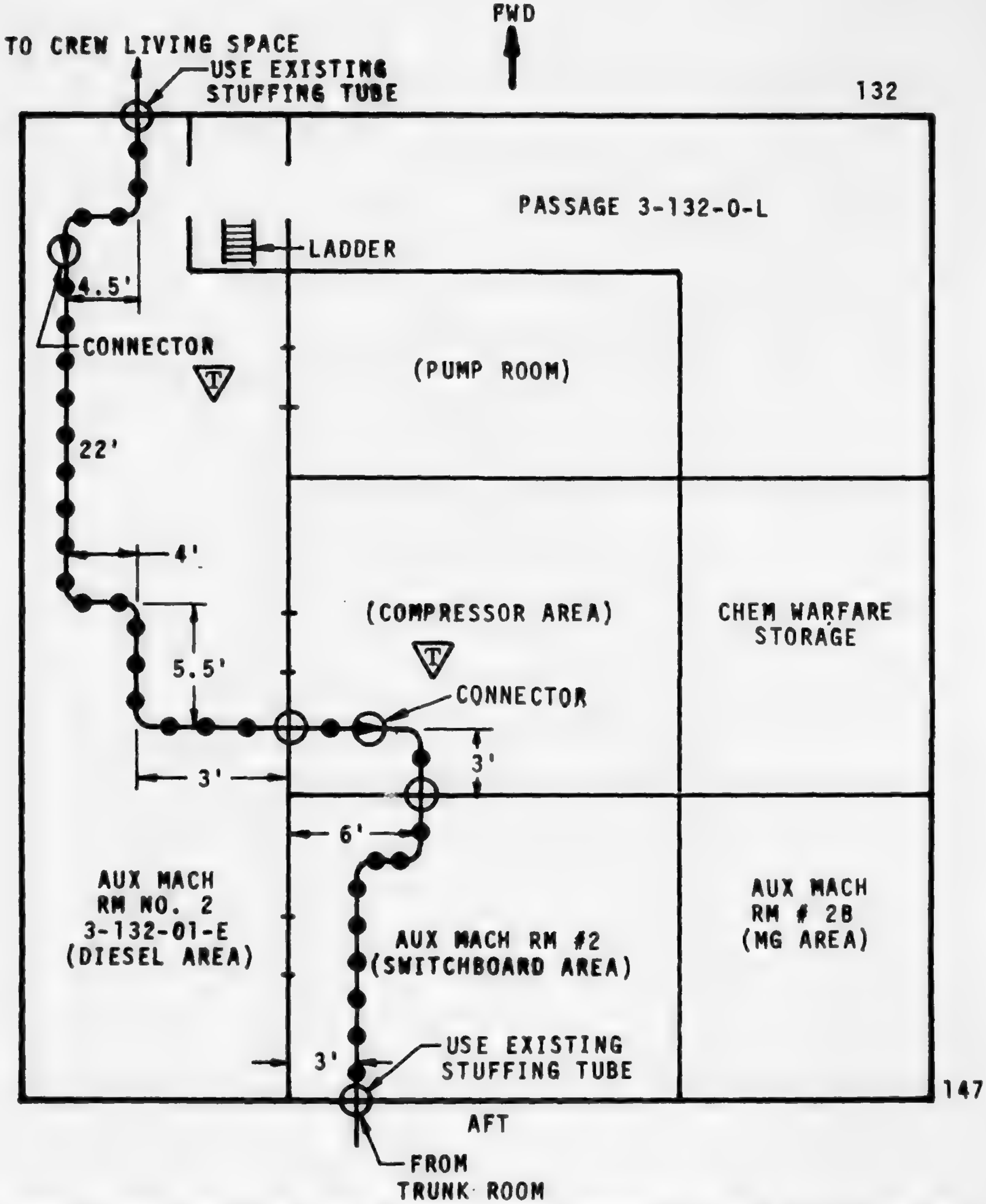
FIG 3-5



NOTE: 1. USE EXISTING CABLEWAYS AND MULTI CABLE TRANSIT FRAMES EXCEPT NOTED STUFFING TUBES

2. APPROX. CABLE LENGTH THIS FIG. = 21 FT

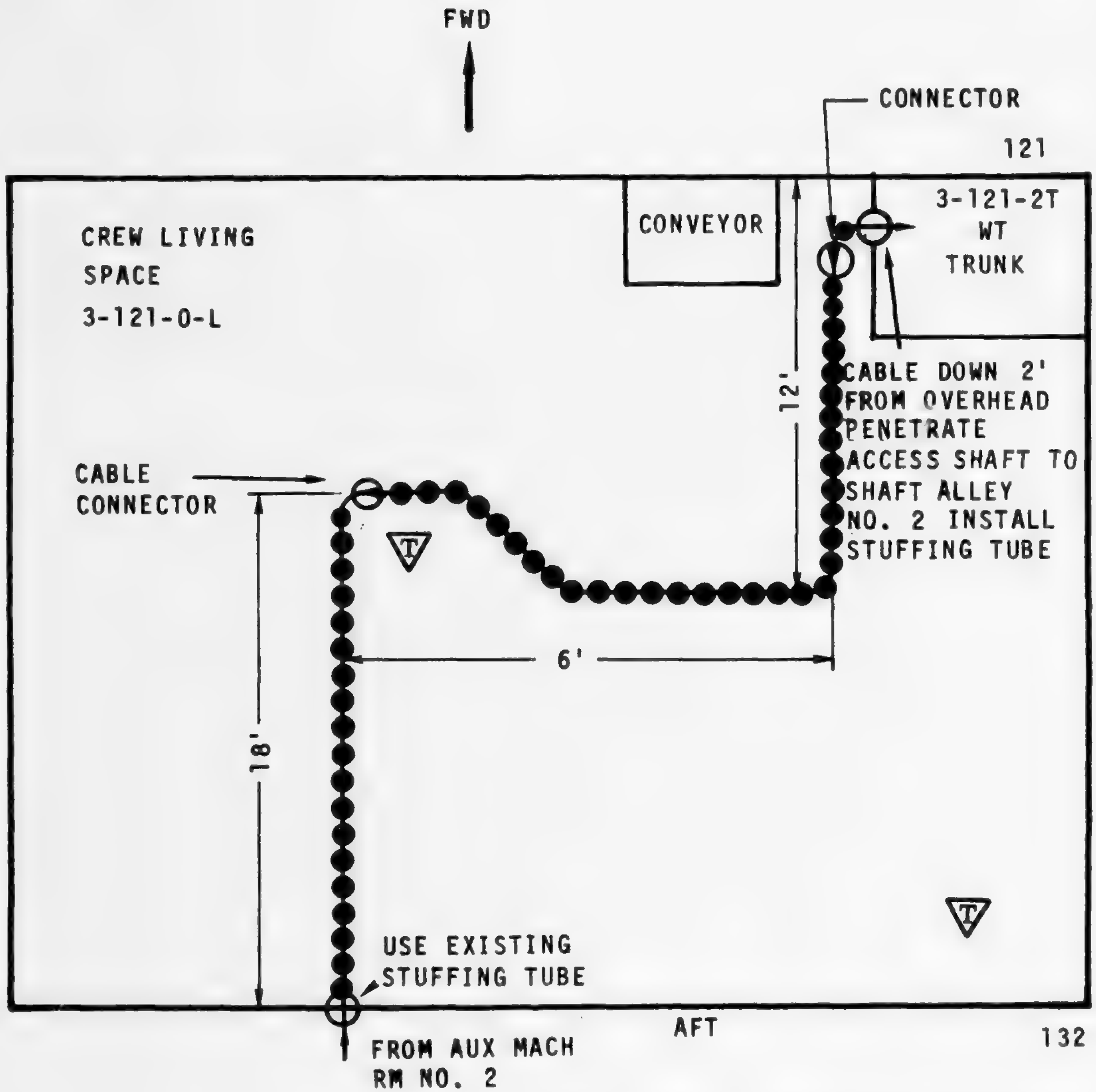
FIG 3-6



NOTE: USE EXISTING CABLEWAYS UNLESS OTHERWISE AND EXISTING MULTI -CABLE TRANSIT FRAMES EXCEPT NOTED STUFFING TUBES.
APPROX CABLE LENGTH THIS FIG. 59 FT.

AUXILIARY MACHINERY ROOM NO. 2 3-132-01-E

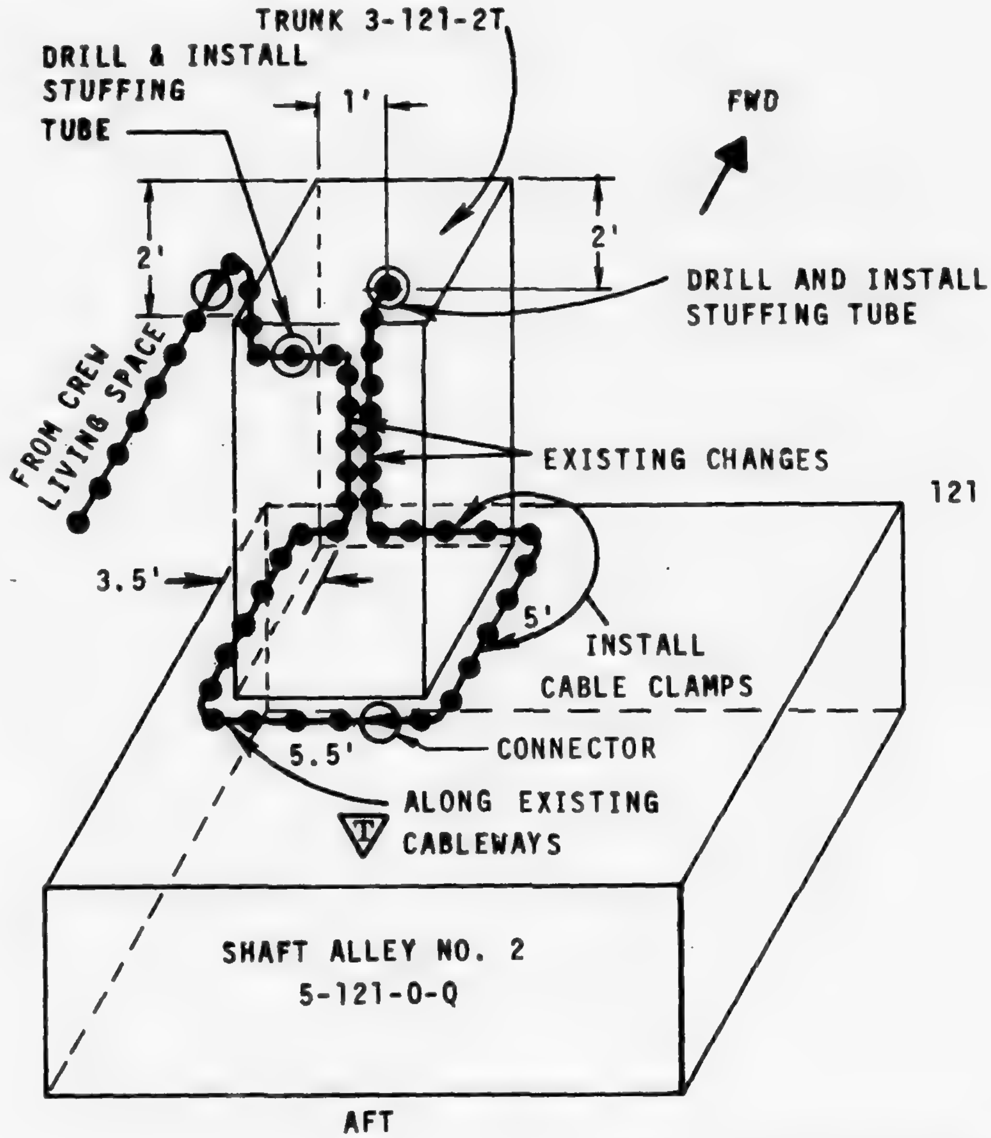
FIG 3-7



NOTE: FOLLOW EXISTING CABLEWAYS

NOTE: APPROX CABLE LENGTH THIS FIG = 38 FT

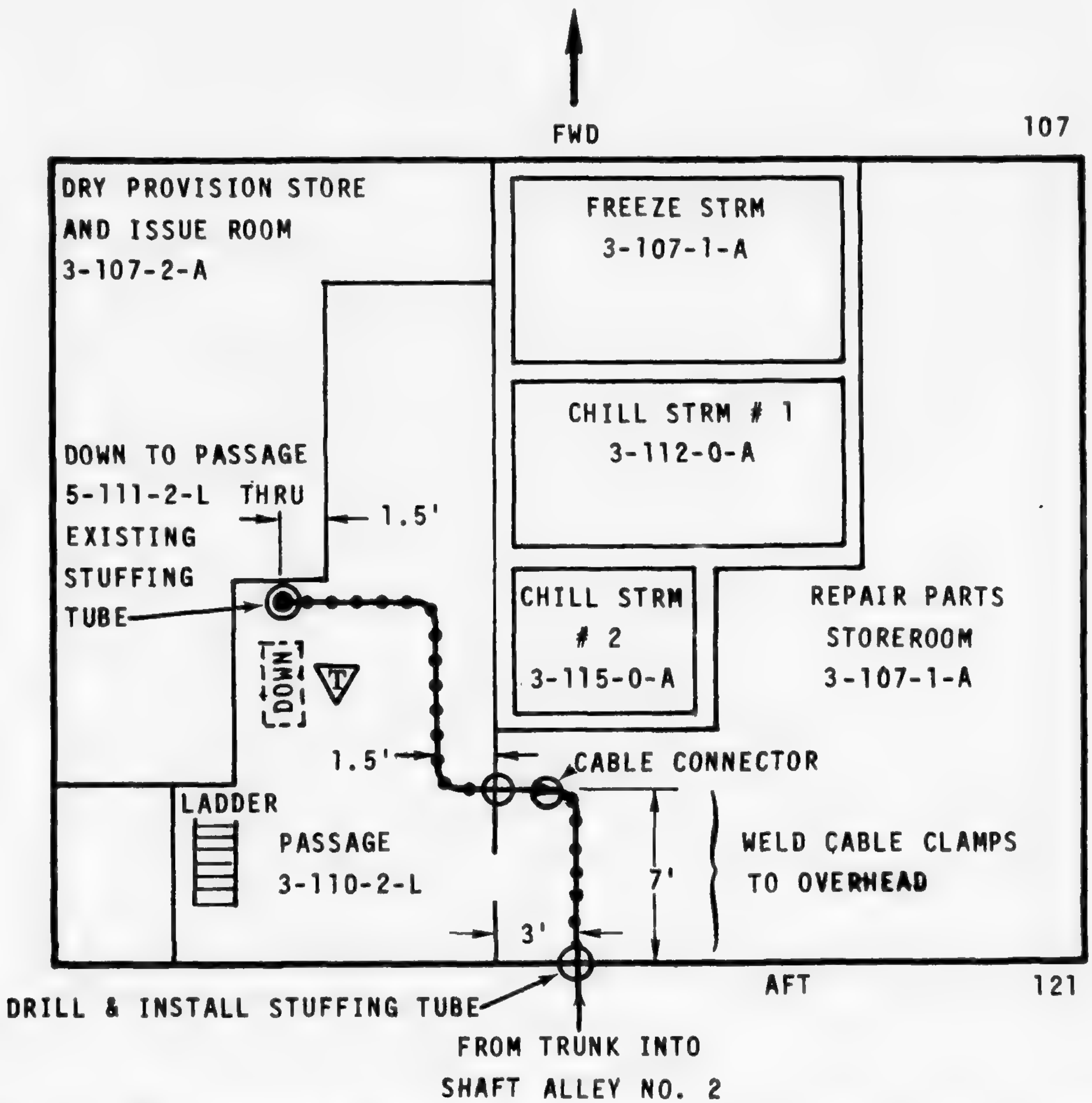
FIG 3-8



NOTE: USE EXISTING CABLEWAYS UNLESS OTHERWISE INDICATED

NOTE: APPROX CABLE LENGTH THIS FIG (INCLUDING VERTICALS) = 36 FT

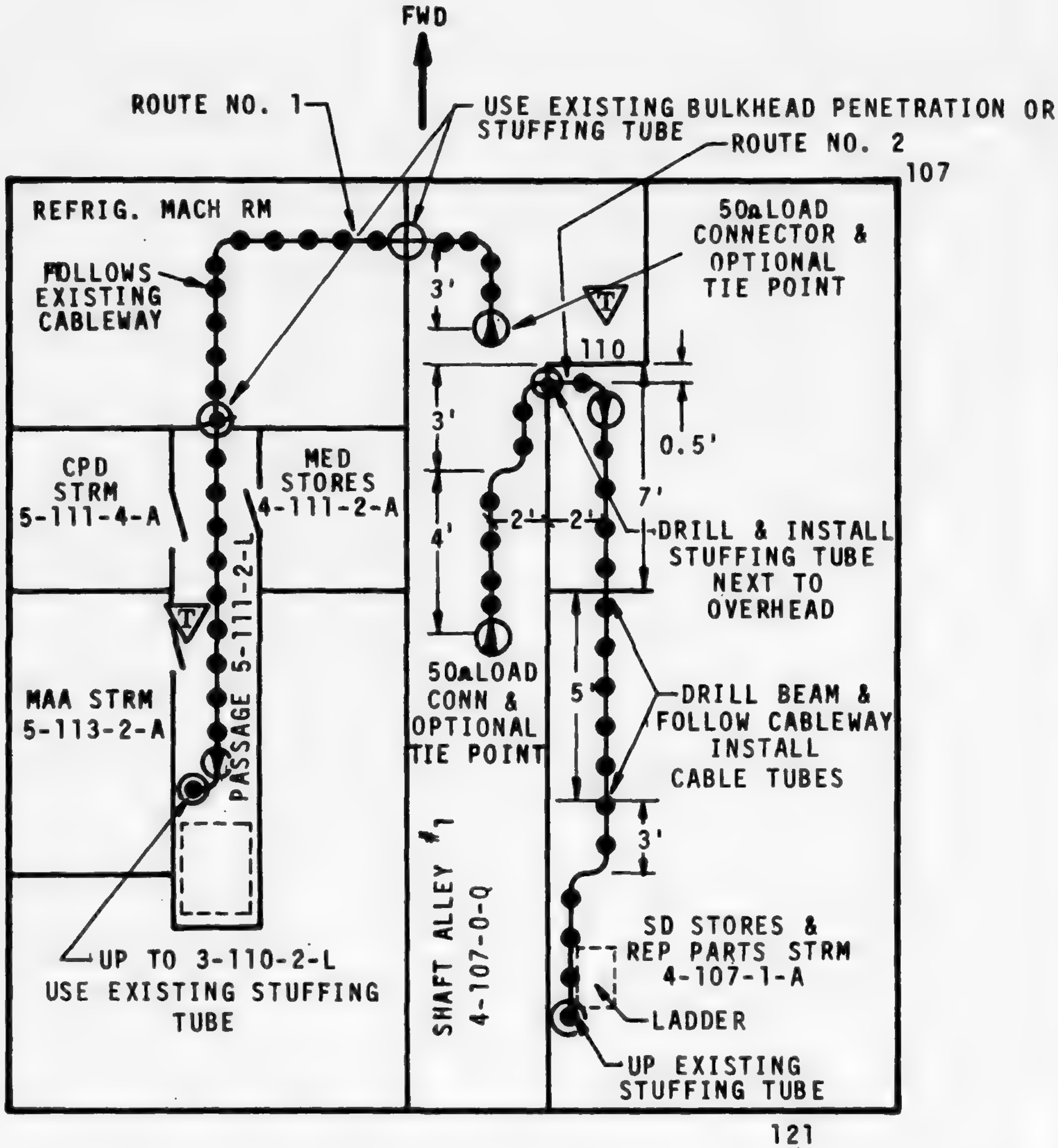
FIG 3-9



NOTE: USE EXISTING CABLEWAYS UNLESS OTHERWISE INDICATED AND EXISTING BULKHEAD PENETRATIONS EXCEPT NOTED STUFFING TUBES.

NOTE: APPROX CABLE LENGTH THIS FIG (INCLUDING VERTICALS) ≈ 32 FT

FIG 3-10



NOTE: APPROX CABLE LENGTH ROUTE 2 ON THIS FIGURE (INCLUDING VERTICALS) = 43 FT

APPROX CABLE LENGTH ROUTE 1 ON THIS FIG ≈ 38 FT.

FIG 3-11

APPENDIX 4

Forward Radiax Route

Base Station at Engine Control Station

SIGNIFICANCE OF SYMBOLS

 DECK PENETRATION OF STUFFING TUBE

 BULKHEAD PENETRATION OR STUFFING TUBE

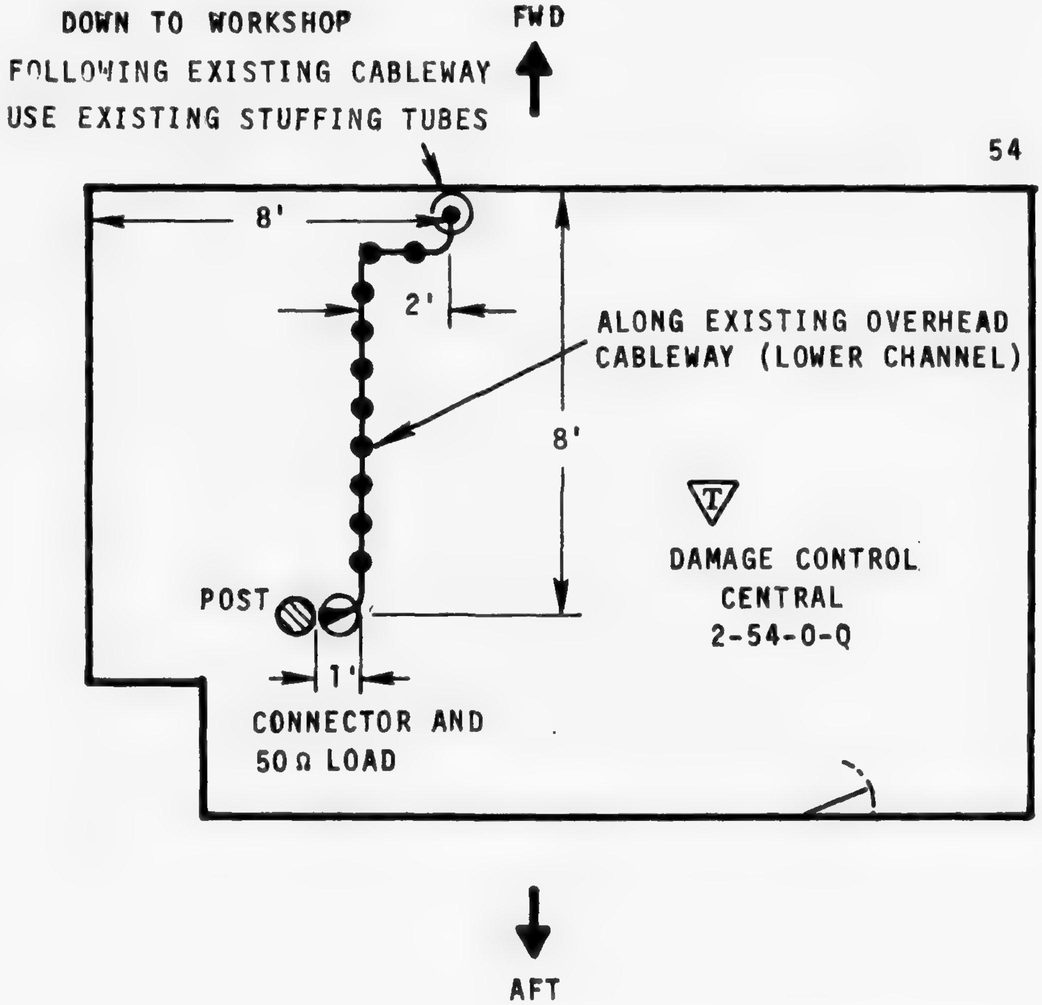
 MULTICABLE TRANSIT FRAME

 CONNECTOR

FEMALE MALE

 CABLE SPLICE

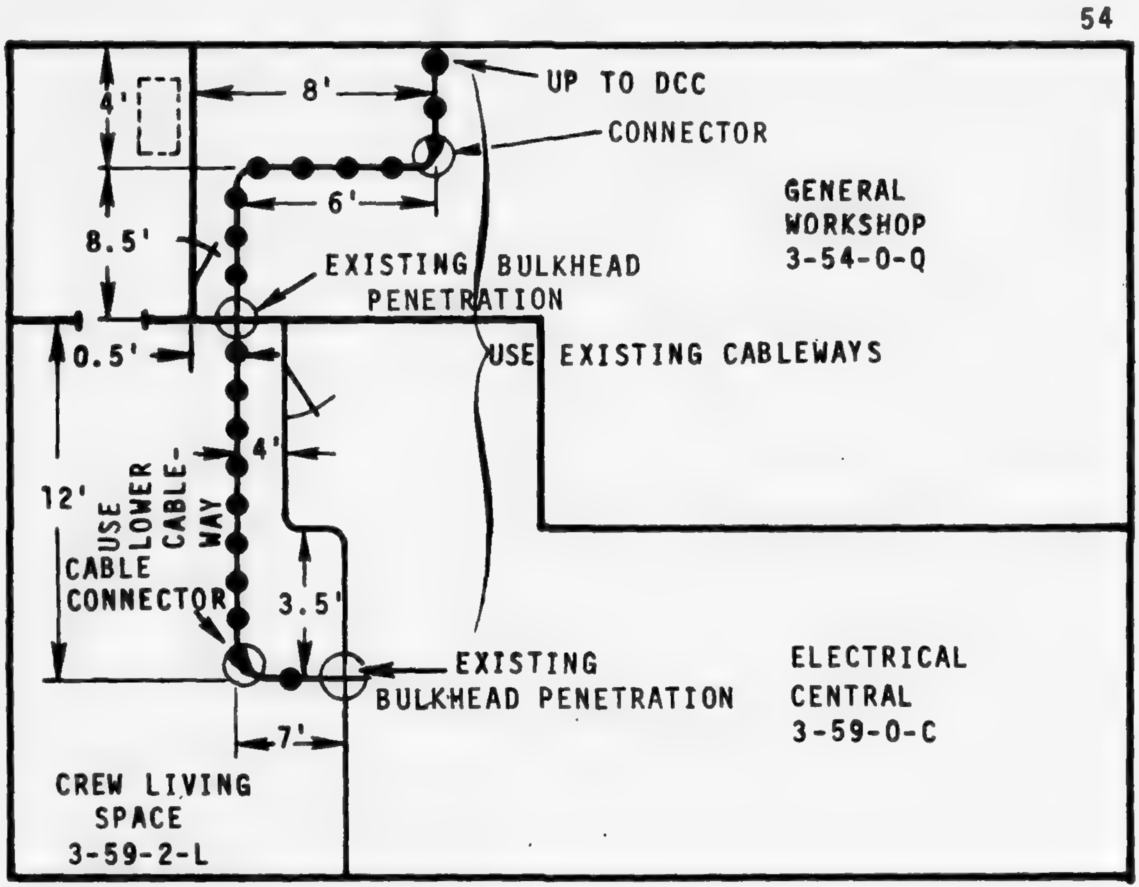
 TRANSCIEVER LOCATION DURING TEST



NOTE: APPROX CABLE LENGTH ON THIS FIG. (INCLUDING VERTICALS) = 23 FT.

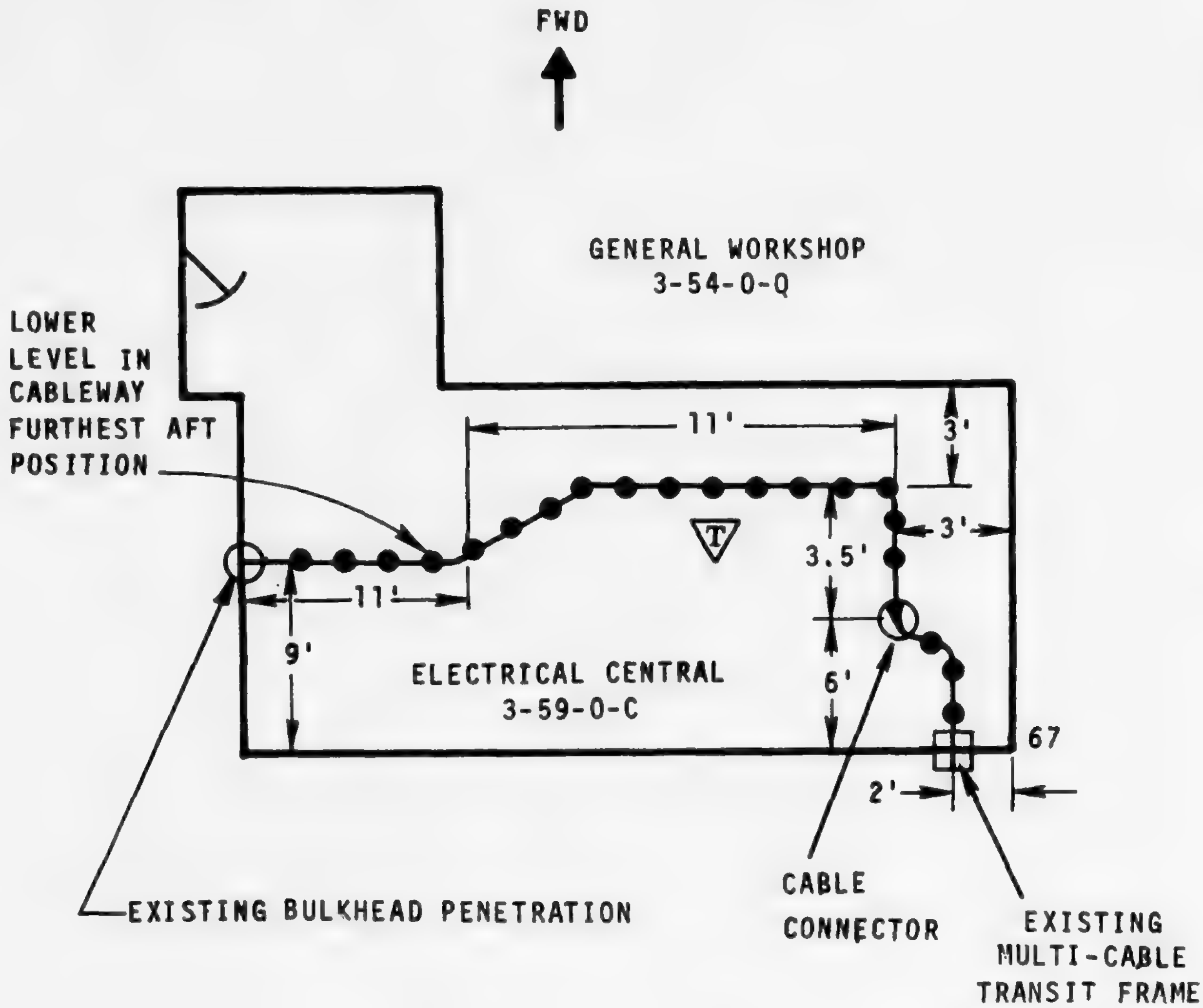
FIG 4-1

FWD



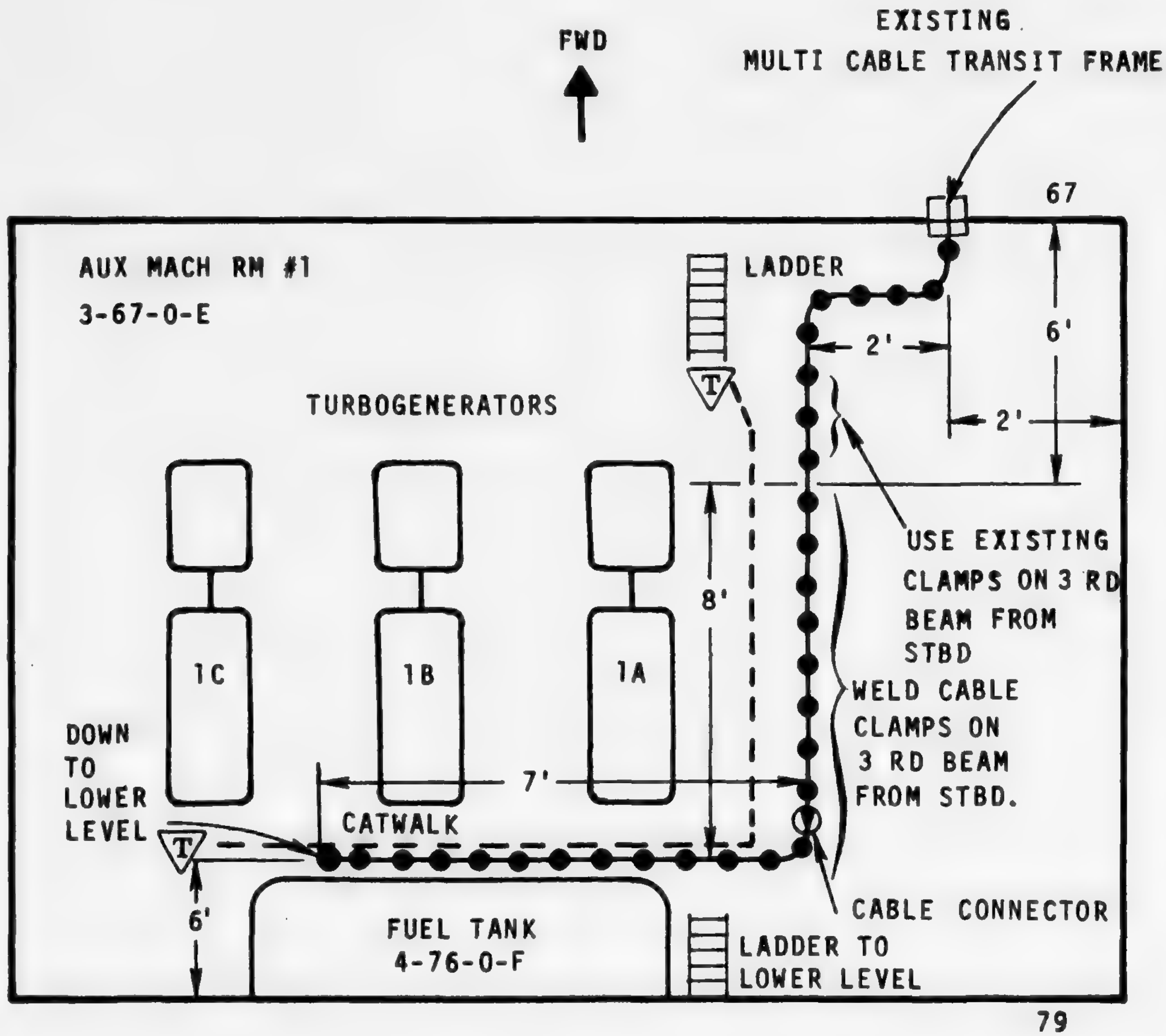
NOTE: APPROX. CABLE LENGTHS ON THIS FIG. = 38 FT

FIG 4-2



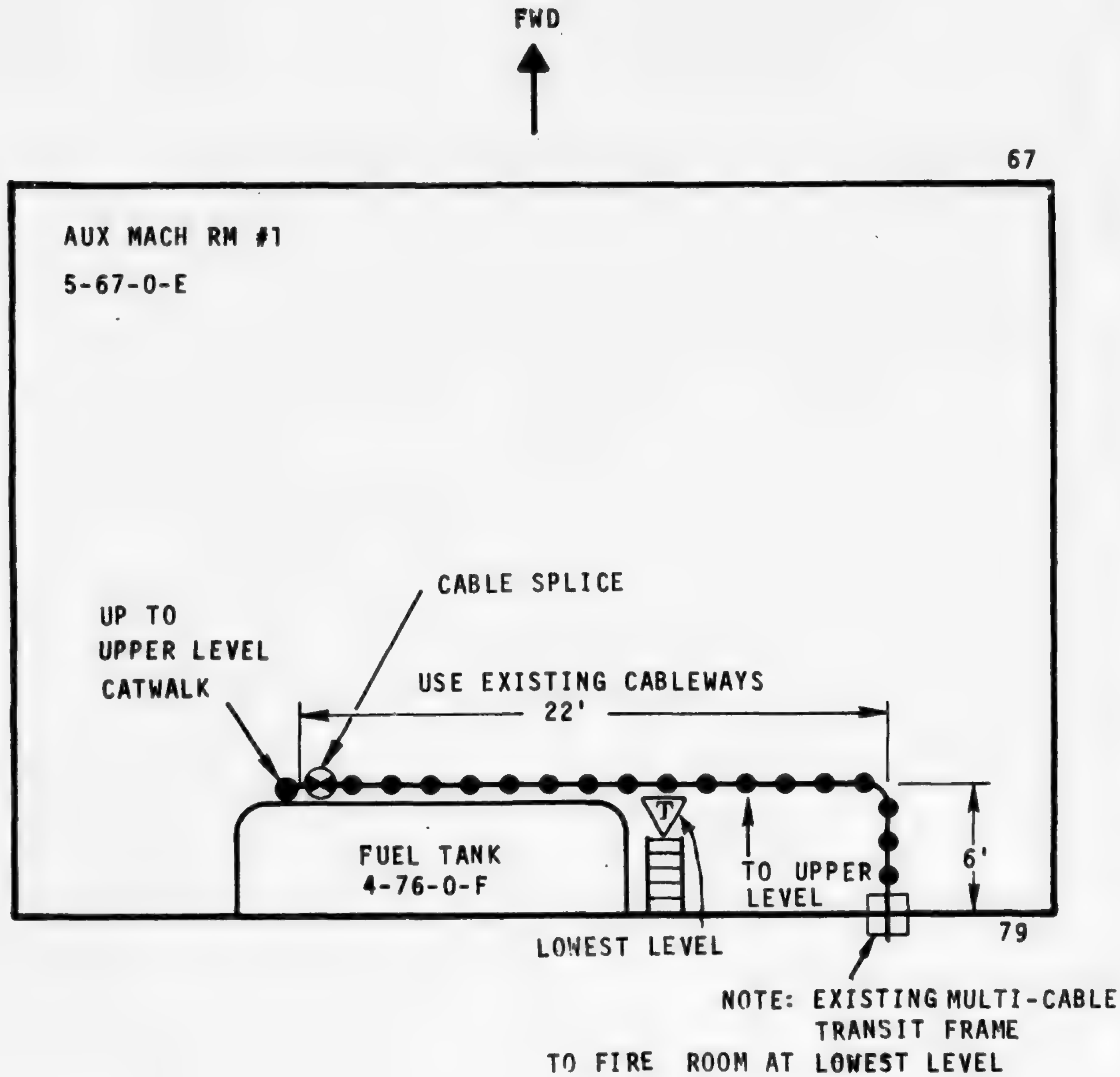
NOTE: APPROX CABLE LENGTHS ON THIS FIG. ≈ 34 FT.

FIG 4-3



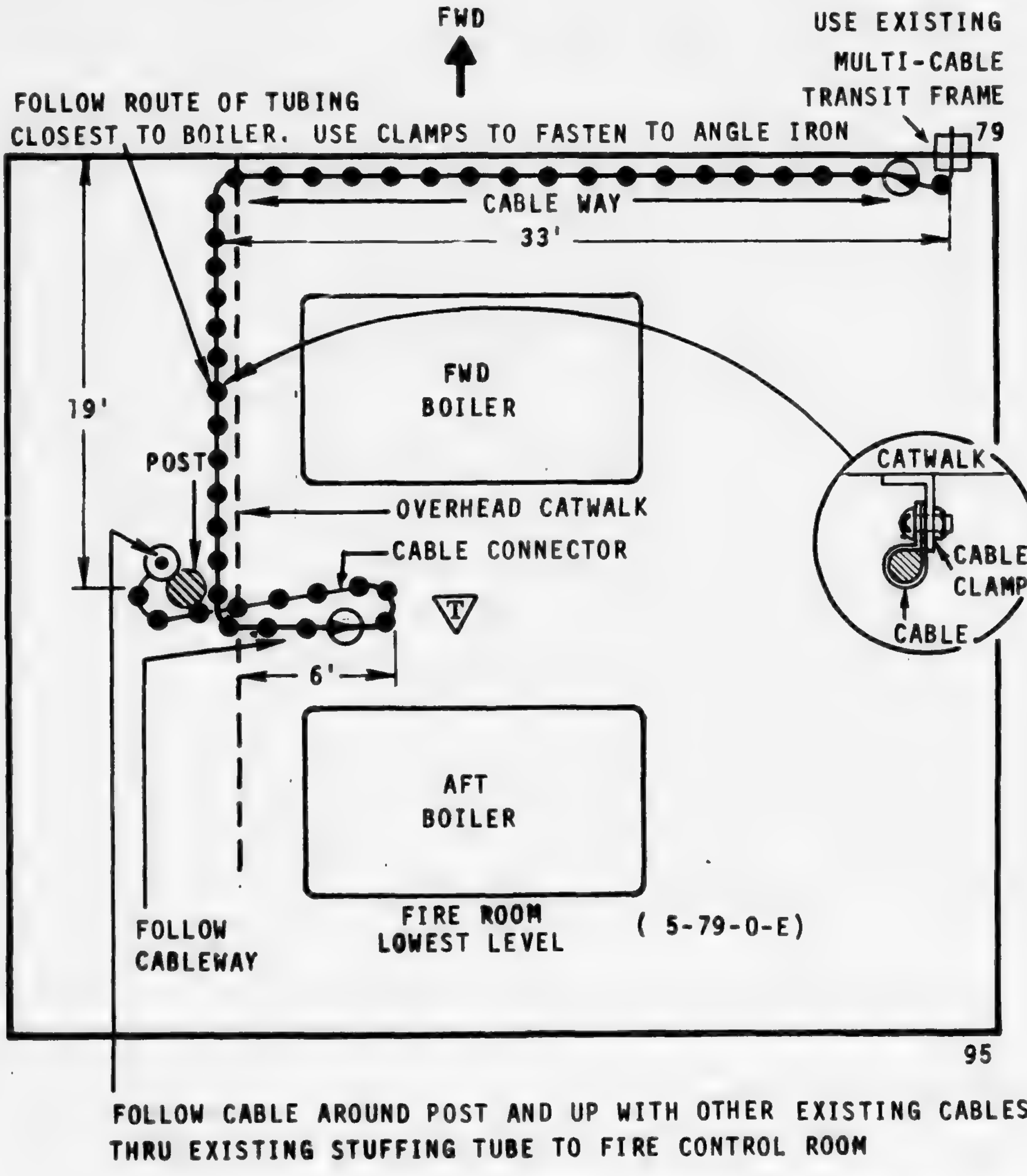
NOTE: APPROX CABLE LENGTHS ON THIS FIG (INCLUDING VERTICALS) = 41 FT

FIG 4-4



APPROX. CABLE LENGTHS IN
THIS FIG. = 28 FT.

FIG 4-5



NOTE: APPROX CABLE LENGTH ON THIS FIG (INCLUDING VERTICALS)≈ 75 FT

FIG 4-6

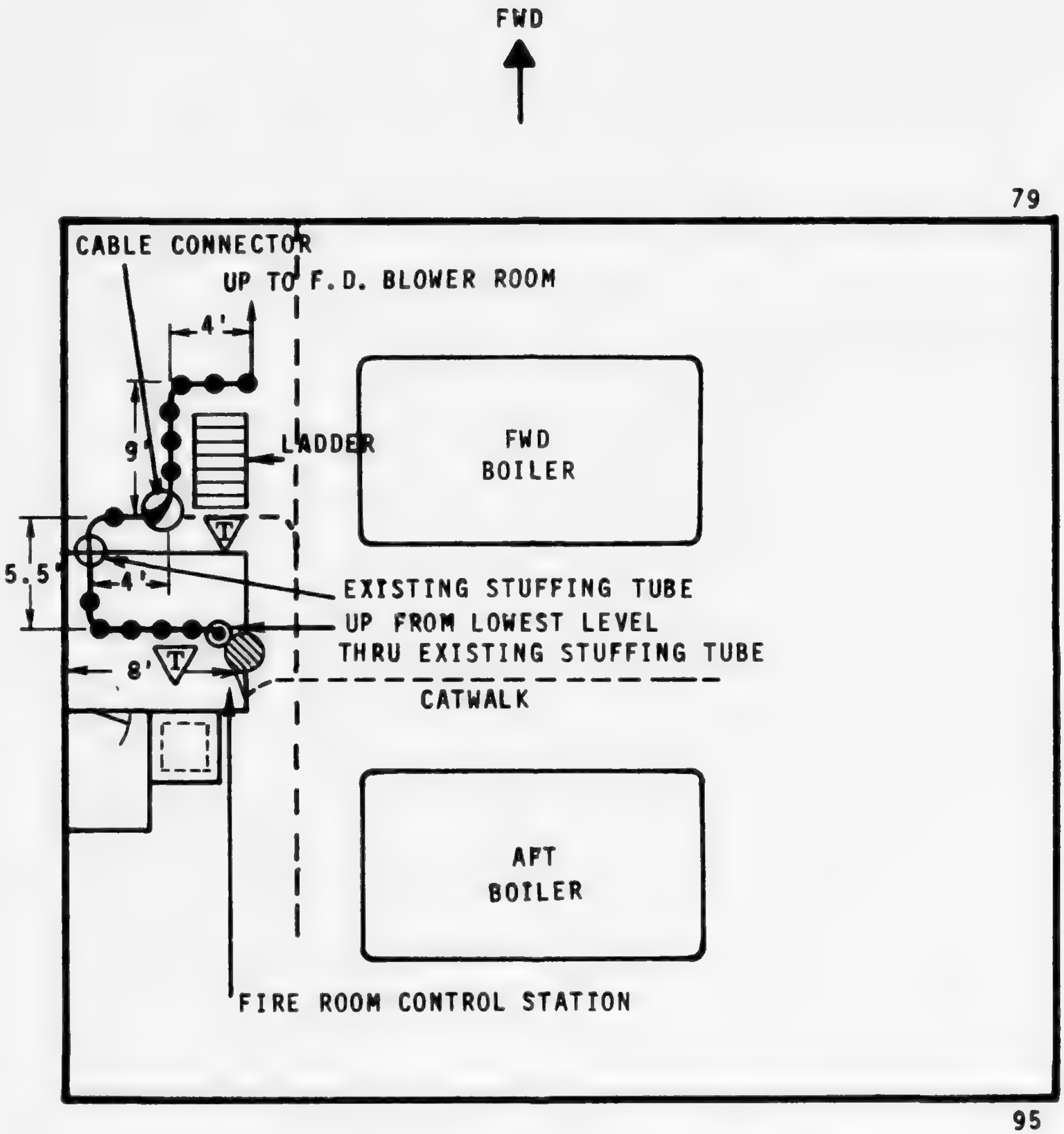


FIG 4-7 NOTE: APPROX CABLE LENGTH ON THIS FIG. (INCLUDING VERTICALS) = 50 FT.

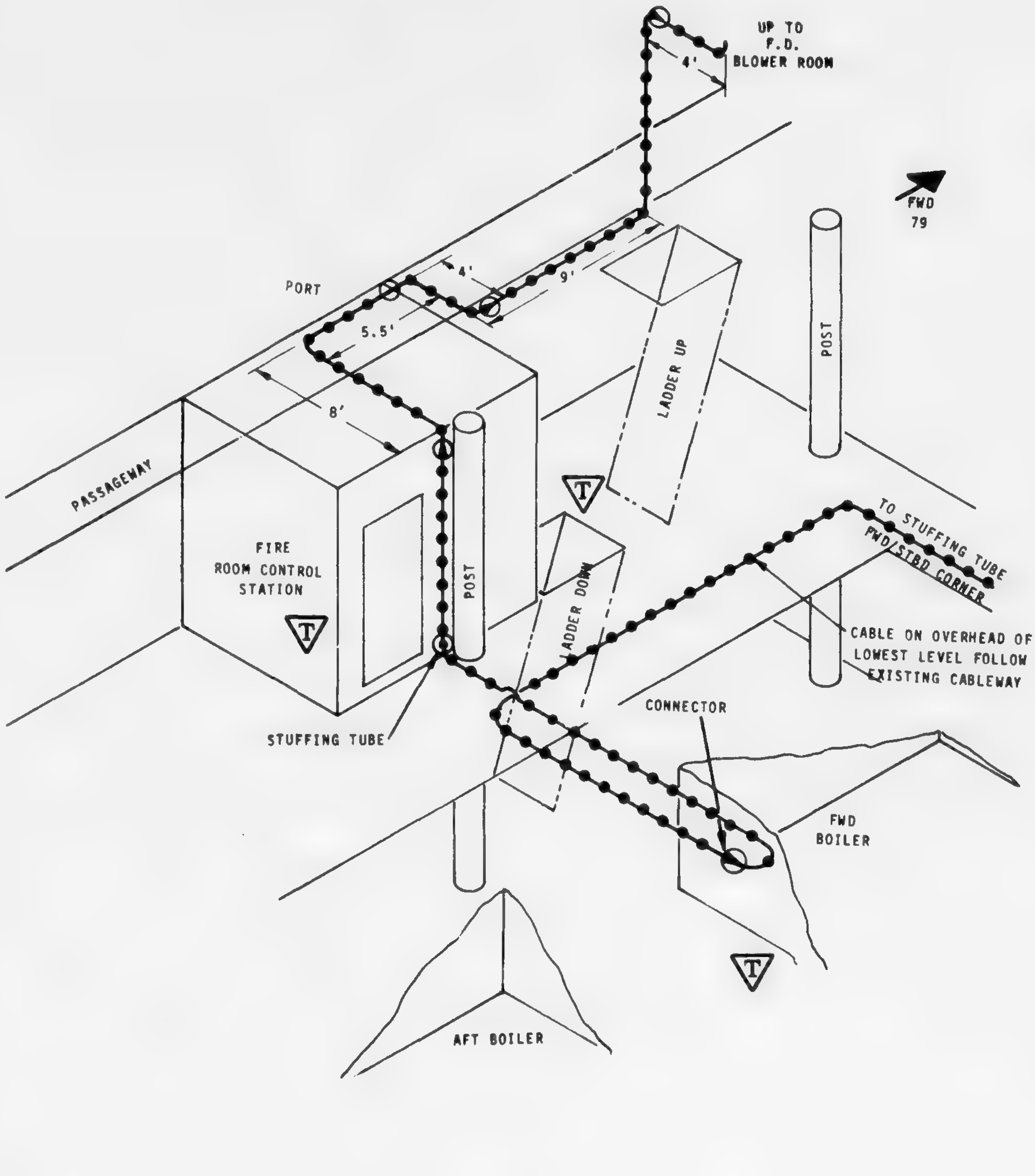

UP TO
F.D.
BLOWER ROOM
4'
FWD
79
PORT
4'
9'
5.5'
8'
LADDER UP
POST
PASSAGEWAY
FIRE
ROOM CONTROL
STATION
POST
LADDER DOWN
TO STUFFING TUBE
FWD/STBD CORNER
CABLE ON OVERHEAD OF
LOWEST LEVEL FOLLOW
EXISTING CABLEWAY
CONNECTOR
STUFFING TUBE
FWD
BOILER
AFT BOILER

FIG 4-8

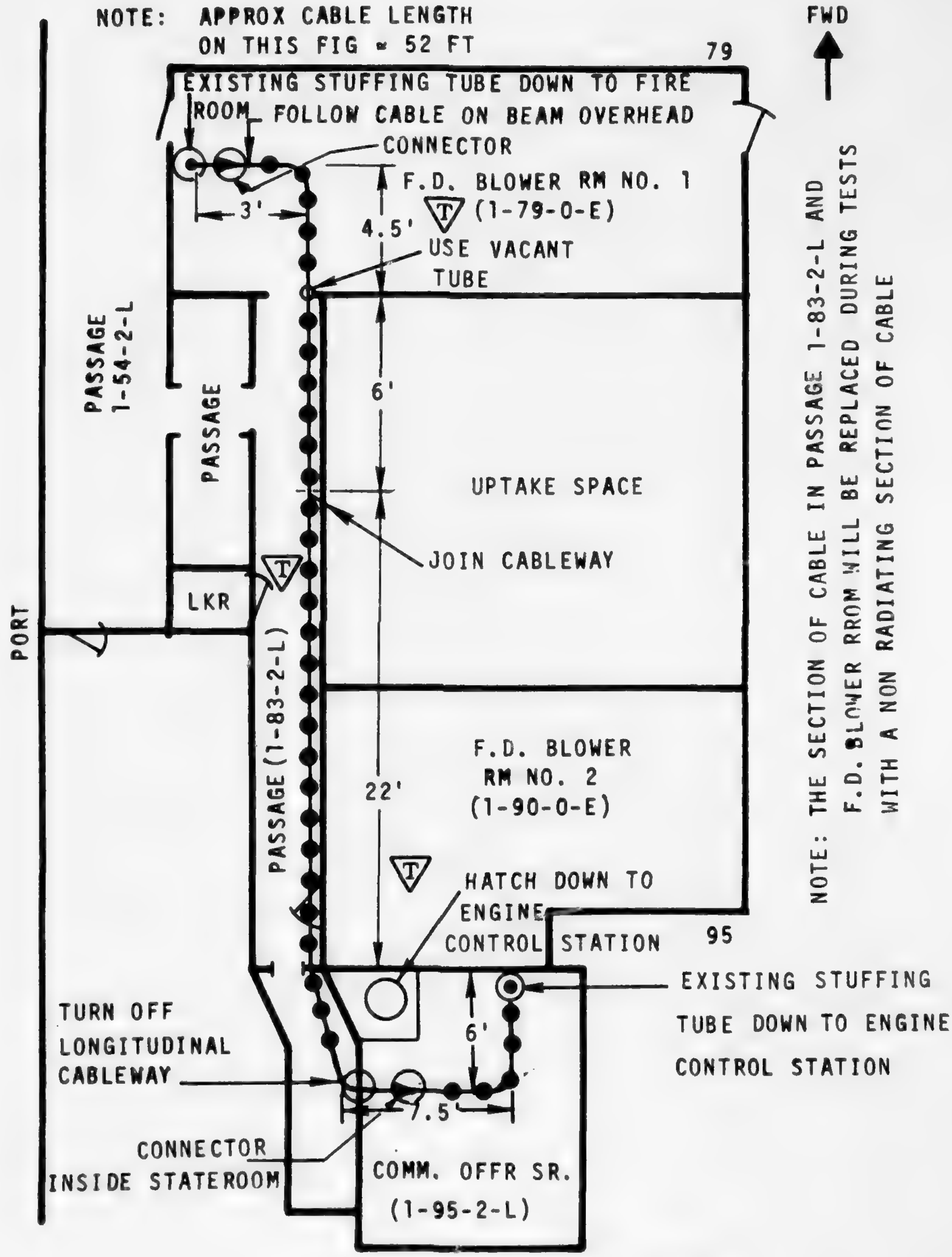
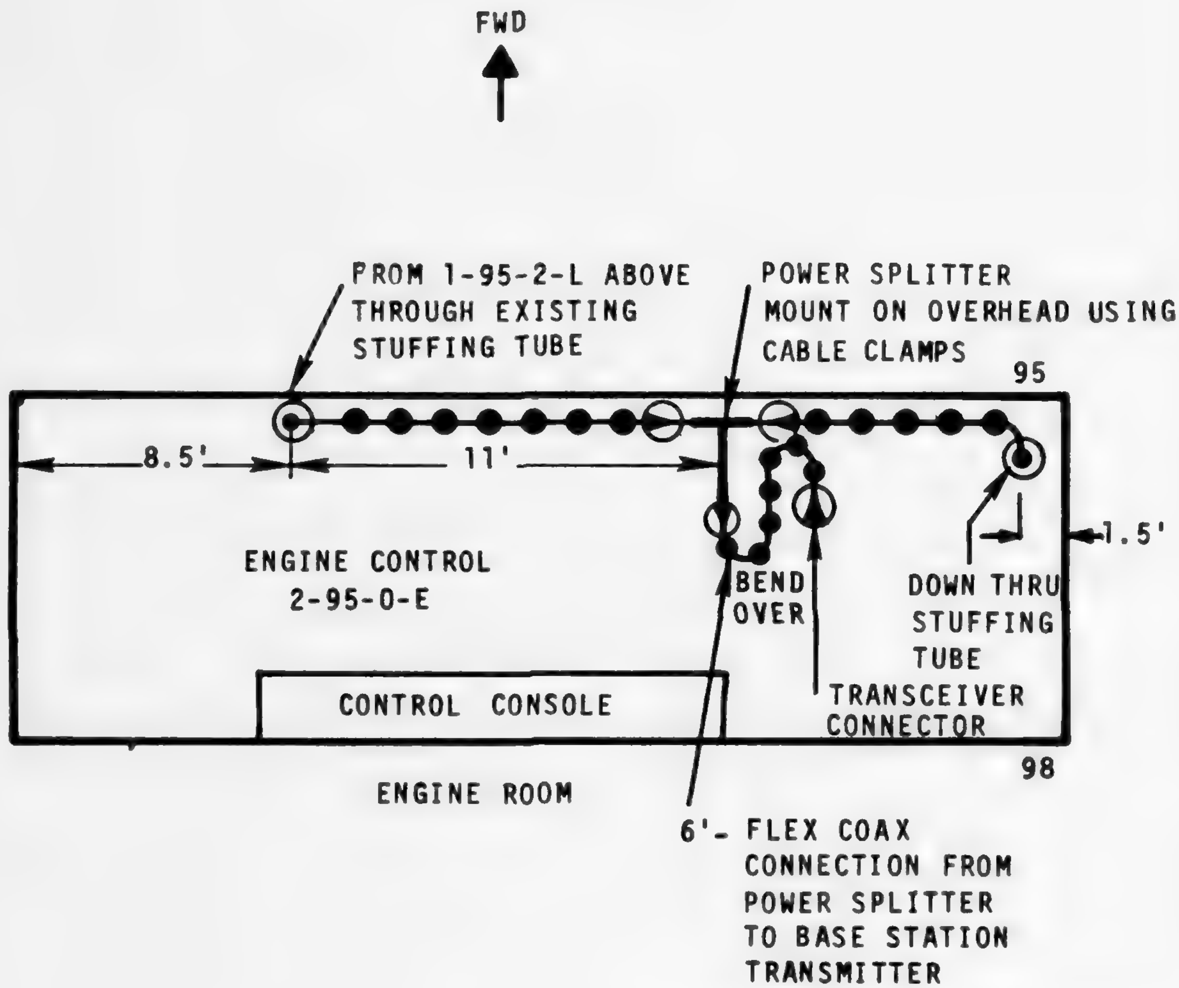

NOTE: APPROX CABLE LENGTH
ON THIS FIG ≈ 52 FT
FWD
79
EXISTING STUFFING TUBE DOWN TO FIRE
ROOM
FOLLOW CABLE ON BEAM OVERHEAD
CONNECTOR
F.D. BLOWER RM NO. 1
(1-79-0-E)
3'
4.5'
USE VACANT
TUBE
PASSAGE
1-54-2-L
PASSAGE
6'
UPTAKE SPACE
JOIN CABLEWAY
LKR
PORT
PASSAGE (1-83-2-L)
F.D. BLOWER
RM NO. 2
(1-90-0-E)
22'
HATCH DOWN TO
ENGINE
CONTROL STATION
95
EXISTING STUFFING
TUBE DOWN TO ENGINE
CONTROL STATION
TURN OFF
LONGITUDINAL
CABLEWAY
6'
7.5
CONNECTOR
INSIDE STATEROOM
COMM. OFFR SR.
(1-95-2-L)
NOTE: THE SECTION OF CABLE IN PASSAGE 1-83-2-L AND
F.D. BLOWER RROM WILL BE REPLACED DURING TESTS
WITH A NON RADIATING SECTION OF CABLE

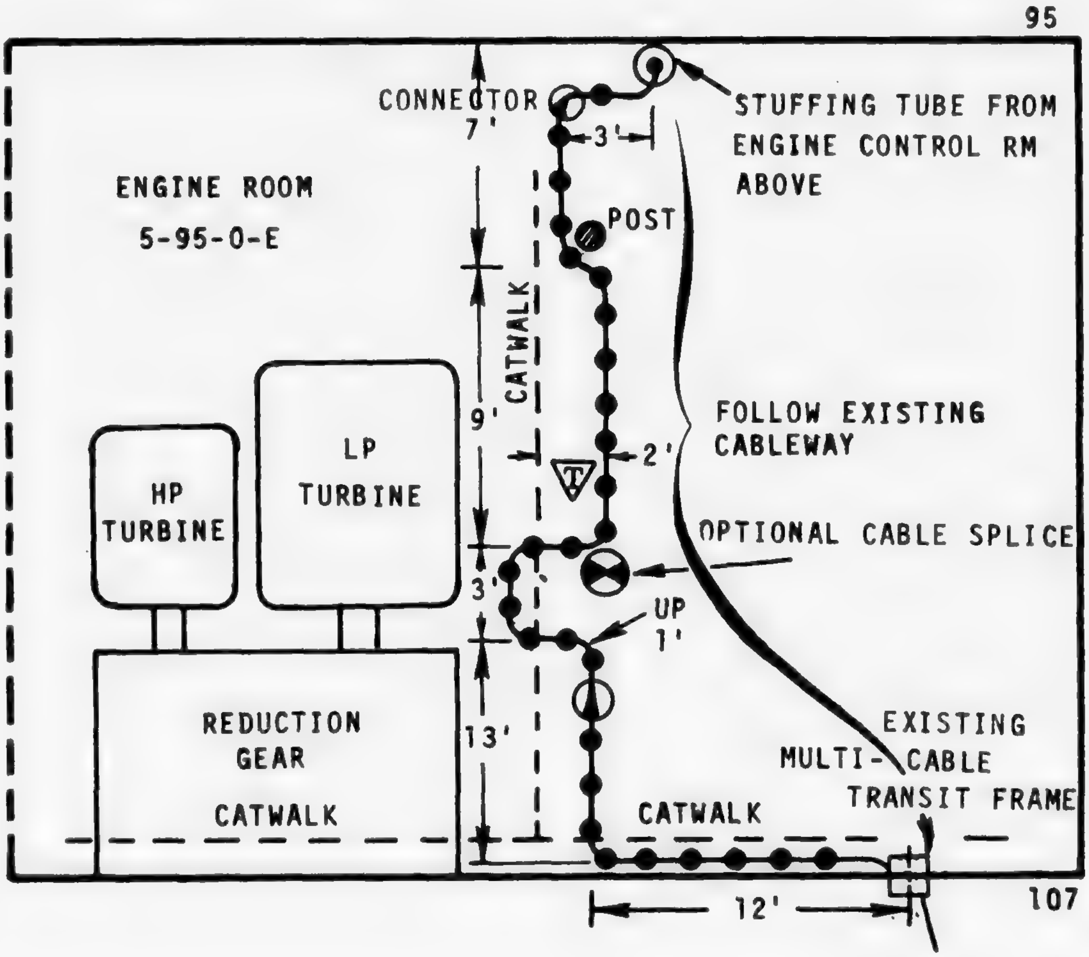
FIG 4-9



NOTE: APPROX CABLE LENGTH ON THIS FIG (INCLUDING VERTICALS) = 38 FT.

FIG 4-10

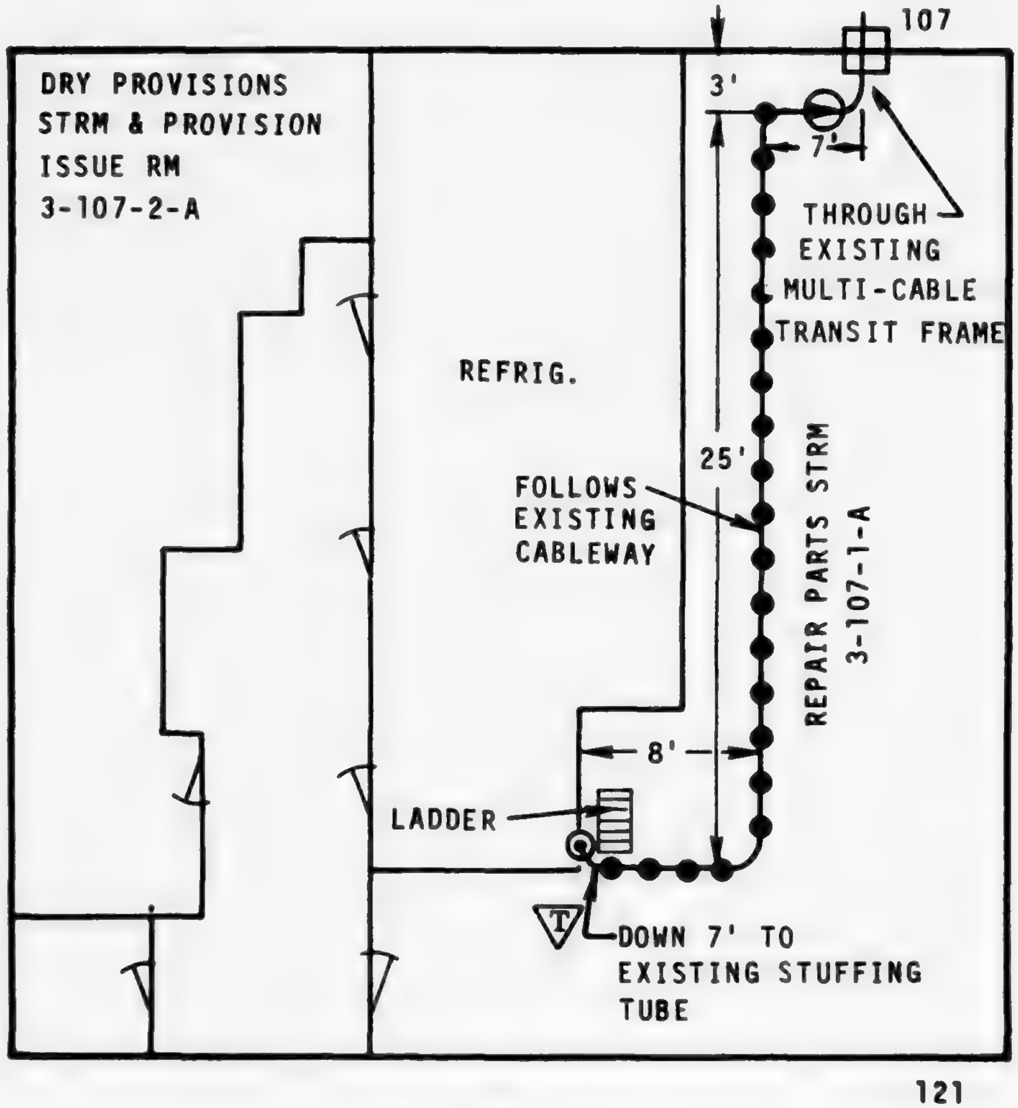
FWD



NOTE: APPROX CABLE LENGTH ON THIS FIG. (INCLUDING VERTICALS) ≈ 59 FT

FIG 4-11

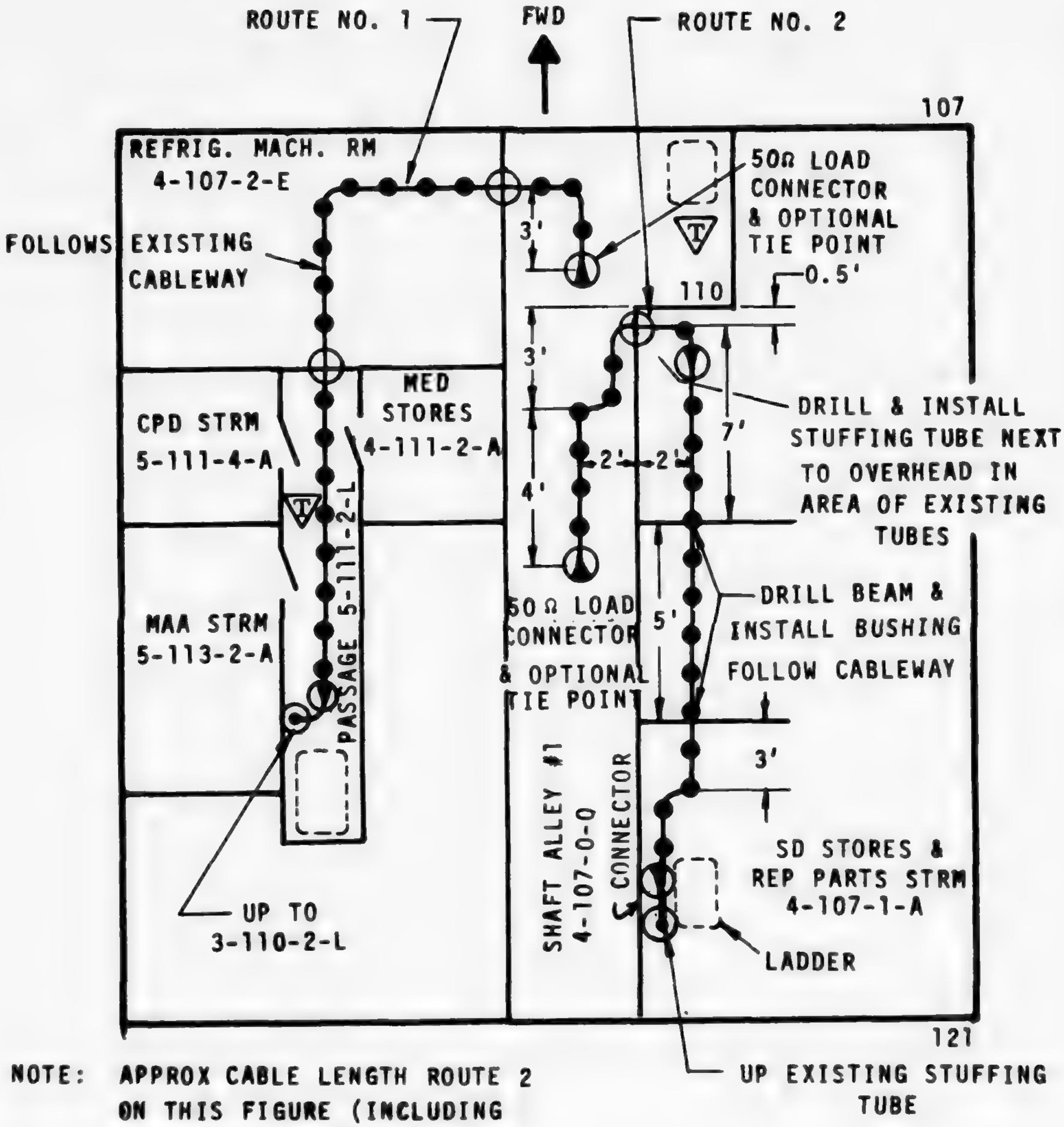
FWD



AFT

NOTE: APPROX CABLE LENGTH ON THIS FIG = 43 FT.

FIG 4-12



NOTE: APPROX CABLE LENGTH ROUTE 2 ON THIS FIGURE (INCLUDING VERTICALS) - 43 FT

FIG 4-13

APPENDIX 5

Penetrations

Several types of bulkhead and deck penetrations applicable to the Radiax installation are found in NAVSEC Drawing No. 9000-S6202-73980. Pertinent sheets from that document are reproduced in this appendix. These are numbered with the same sheet numbers as in 73980. The applicable sheets are indexed below.

	Bulkhead Penetration	Deck Penetration
Non-watertight	Sheet 18, 20, 21 1, 2	26 1, 2
Watertight, single cable	Sheet 14 1, 2	13 1, 2
Watertight, multicable	Sheet 170 - 173	

The MIL-S-24235 stuffing tube is size C for .625 cable, Assembly M24235/9-003 and requires packing assembly MIL-P-16685D, size C. The tube fits 3/4" pipe.

The MIL-S-19622 stuffing tube is size 4T. The pipe version on sheet 13 is M-19622/3-005. It fits a 1" pipe nipple. The style pictured in method 4144, sheet 14, is M-19622/1-004. Both require packing assembly M-19622/19-0004.

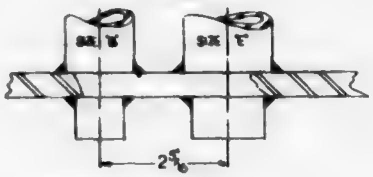
To use the multicable transit frame of sheet 172 one of the proper size blank blocks must be replaced with a size 30/15. The block is 30 mm or 1.18 inch square. A double size block (2.36" square) could be replaced with one 30/15 and three 30/0 sizes.

The ship's engineering officer should determine the appropriate optional method. Thus, where welding would be objectionable because of proximity to other cables, method 4262 might be selected in preference to 4261 (sheet 26). Minimum spacing of tubes is called out in sheet 2 but on-site conditions may dictate other spacing. If the available spaces in the multicable transit frame are wrong size the position of a welded pipe to accept an M-24235 stuffing tube should be determined by the ship's engineering officer.

HOLE SPACING IN DECKS AND BULKHEADS
(FROM DESIGN DATA SHEET DDS1100-2)

411

EXAMPLE



NOTES-

1. THE TABLE REFERRED TO IN THE FOLLOWING NOTES IS THE HOLE SPACING TABLE ON SHEET 2.
2. THE DIMENSIONS SHOWN IN THE HOLE SPACING TABLE ARE SUITABLE FOR THE PIERCING OF SPECIAL TREATMENT STEEL, HIGH TENSILE AND MEDIUM STEEL DECKS AND BULKHEADS.
3. THIS TABLE MAY BE USED FOR ALL PLATE THICKNESSES NOT EXCEEDING 3 INCHES. THIS TABLE DOES NOT APPLY TO ARMOR.
4. THIS TABLE MAY ALSO BE USED FOR ALUMINUM AND BRASS DECKS AND BULKHEADS WHERE INSTALLATION OF STUFFING TUBES ARE REQUIRED.
5. THE VALUES OF THE TABLE ARE MINIMUM PERMITTED VALUES, AND MAY BE INCREASED AS JUDGED TO BE DESIRABLE FOR ANY PARTICULAR APPLICATION.
6. USE OF THIS TABLE DOES NOT REQUIRE ANY INCREASE IN THICKNESS OF PLATING, OR ADDITION OF DOUBLER PLATES. THE METAL RESTORED TO A PLATE BY THE MOUNTING OF STUFFING TUBES OR THE PASSING OF PIPE IS ADEQUATE COMPENSATION FOR THE METAL REMOVED FROM THE PLATE DUE TO ANY DRILLING OF HOLES IN ACCORDANCE WITH THE TABLE, AND LIMITATIONS OF NOTE 2.
7. THIS TABLE IS APPLICABLE TO THE GREAT MAJORITY OF INSTALLATIONS. EXCEPTIONS TO THE TABLE ARE RECOGNIZED WHEN IT IS EXPEDIENT TO MOUNT STUFFING TUBES ON ALTERNATE SIDES OF THE PLATE BEING PIERCED, AND WHEN SPECIAL FITTINGS ARE REQUIRED IN PASSING ELECTRIC CABLES THROUGH THE PRESSURE HULL OF SUBMARINES INTO CONNING TOWER TRUNKS, OR AS OTHERWISE NOTED IN THIS INSTALLATION DRAWING.
8. FOR STRENGTH PRESERVATION OF BOTH MEDIUM AND SPECIAL TREATMENT STEEL PLATINGS, STUFFING TUBE HOLE SPACINGS SHALL IN NO CASE BE LESS THAN 1.9 MEAN DIAMETERS OF ANY TWO ADJACENT HOLES. FOR MEDIUM STEEL CALCULATIONS, FOR THE HOLE DIAMETERS USE THE INTERNAL DIAMETERS OF THE EXTRA STRONG KICKPIPES. FOR SPECIAL TREATMENT STEEL, USE THE ACTUAL DRILLED HOLE DIAMETERS GIVEN IN COLUMN THREE OF THE TABLE.
9. IN LOCATING A HOLE FROM A BOUNDRY STRUCTURAL MEMBER OR CABLE SUPPORT THE DISTANCE SHALL NOT BE LESS THAN HALF THE CENTER TO CENTER SPACING GIVEN IN THE TABLE FOR TWO TUBES OF THE REQUIRED SIZE.
10. THIS TABLE DOES NOT IMPOSE ANY RESTRICTIONS ON HOW THE HOLES SHALL BE ARRANGED AS LONG AS THE RESTRICTION REGARDING MINIMUM ALLOWABLE SPACING IS NOT VIOLATED.
11. THE SPACINGS FOR TUBE SIZES "B" THROUGH "Z" ARE SUFFICIENT FOR THE USE OF THE STANDARD OPEN RATCHET WRENCHES, SPEC MIL-W-15039. THE SPACINGS FOR TUBE SIZES "AA" AND "BB" ARE SUFFICIENT FOR THE USE OF 32 POINT BOX TYPE CROWFOOT WRENCHES WITH SQUARE DRIVE, BUREAU DEVELOPED. THIS DOES NOT HOWEVER EXCLUDE THE USE OF OTHER TYPES OF WRENCHES SUITABLE FOR THE PURPOSE.

NAVY DEPARTMENT — BUREAU OF SHIPS — WASHINGTON D.C.

ELECTRIC PLANT INSTALLATION
STANDARD METHODS
MINIMUM SPACING OF HOLES FOR STUFFING TUBES AND KICKPIPES IN METAL DECKS AND BULKHEADS

EXAMINED — OFFICIAL SIGNATURE

REVIEWED — TRACED — DRAWN

SECTION 4
SHEET 1

9000	S6202	7398C

SCALE - NONE

HOLE SPACING IN DECKS AND BULKHEADS

REPRODUCED FROM DESIGN DATA SHEET DDS100-2

SPACING OF HOLES FOR STUFFING TUBES AND KICKPIPES

THIS TABLE DOES NOT APPLY TO ARMOR PLATE

NOMINAL DIA OF KICKPIPE	DRILL FOR PIPE (MEDIUM STEEL ONLY)	DRILL FOR PIPE (SPECIAL TREATMENT STEEL)	TUBE SIZE	A	B	C	D	E	F	G	J	K	L	M	N	P	R	S	T	V	W	X	Y	Z	AA	BB
3/8	23/32	.406	A	1 15/16																						
1/2	7/8	.515	B	2	2																					
3/4	1 3/32	.640	C	2 1/16	2 1/16	2 1/16																				
3/4	1 3/32	.750	D	2 1/4	2 5/16	2 3/8	2 7/16																			
1	1 21/64	.812	E	2 1/4	2 5/16	2 3/8	2 1/2	2 1/2																		
1	1 21/64	.843	F	2 1/4	2 5/16	2 3/8	2 1/2	2 1/2	2 1/2																	
1	1 21/64	.953	G	2 3/4	2 13/16	2 7/8	2 15/16	3	3	3 1/16																
1 1/4	1 45/64	1.062	J	2 3/4	2 13/16	2 7/8	2 15/16	3	3	3 3/16	3 3/16															
1 1/4	1 45/64	1.171	K	2 3/4	2 13/16	2 7/8	2 15/16	3	3	3 3/16	3 3/16	3 3/16														
1 1/4	1 45/64	1.265	L	2 3/4	2 13/16	2 7/8	2 15/16	3	3	3 1/4	3 1/4	3 1/4	3 1/4													
1 1/2	1 15/16	1.406	M	2 3/4	2 13/16	2 7/8	2 15/16	3	3	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8												
1 1/2	1 15/16	1.515	N	3 5/16	3 3/8	3 7/16	3 1/2	3 9/16	3 9/16	3 11/16	3 3/4	3 13/16	3 13/16	3 15/16	4											
2	2 13/32	1.625	P	3 5/16	3 3/8	3 7/16	3 1/2	3 9/16	3 9/16	3 11/16	3 3/4	3 13/16	3 13/16	3 15/16	4 1/8	4 1/8										
2	2 13/32	1.750	R	3 5/16	3 3/8	3 7/16	3 1/2	3 9/16	3 9/16	3 11/16	3 3/4	3 13/16	3 13/16	3 15/16	4 1/8	4 1/8	4 1/8									
2	2 13/32	1.875	S	3 5/16	3 3/8	3 7/16	3 1/2	3 9/16	3 9/16	3 11/16	3 3/4	3 13/16	3 13/16	3 13/16	4 5/16	4 5/16	4 5/16	4 5/16								
2 1/2	2 29/32	2.062	T	3 5/16	3 3/8	3 7/16	3 1/2	3 9/16	3 9/16	3 13/16	3 13/16	3 13/16	3 13/16	3 13/16	4 7/16	4 7/16	4 7/16	4 7/16	4 7/16							
2 1/2	2 29/32	2.187	V	3 11/16	3 3/4	3 13/16	3 7/8	3 15/16	3 15/16	4 1/16	4 1/8	4 3/16	4 1/4	4 5/16	4 7/16	4 1/2	4 1/2	4 11/16	4 3/4	4 13/16						
2 1/2	2 29/32	2.312	W	3 11/16	3 3/4	3 13/16	3 7/8	3 15/16	3 15/16	4 1/16	4 1/8	4 3/16	4 1/4	4 5/16	4 1/2	4 1/2	4 1/2	4 11/16	4 3/4	4 7/8	4 7/8					
3	3 17/32	2.500	X	3 11/16	3 3/4	3 13/16	3 7/8	3 15/16	3 15/16	4 1/8	4 1/8	4 3/16	4 1/4	4 5/16	4 11/16	4 11/16	4 11/16	4 11/16	4 3/4	5 1/16	5 1/16	5 1/16				
3	3 17/32	2.609	Y	3 11/16	3 3/4	3 13/16	3 7/8	3 15/16	3 15/16	4 1/8	4 1/8	4 3/16	4 1/4	4 5/16	4 11/16	4 11/16	4 11/16	4 11/16	4 3/4	5 1/16	5 1/16	5 1/16	5 1/16			
3	3 17/32	2.781	Z	3 11/16	3 3/4	3 13/16	3 7/8	3 15/16	3 15/16	4 1/8	4 1/8	4 3/16	4 1/4	4 5/16	4 3/4	4 3/4	4 3/4	4 3/4	4 3/4	5 1/8	5 1/8	5 1/8	5 1/8	5 5/16		
3	3 17/32	2.875	AA	3 13/16	3 7/8	3 15/16	4	4	4 1/32	4 5/32	4 1/4	4 9/32	4 5/16	4 7/16	4 15/32	4 5/8	4 19/32	4 25/32	4 31/32	4 31/32	5 1/16	5 9/16	5 9/16	5 9/16	5 17/32	
3 1/2	4 1/32	3.156	BB	4	4 1/16	4 1/8	4 3/16	4 3/16	4 7/32	4 11/32	4 7/16	4 15/32	4 1/2	4 5/8	4 21/32	5 1/16	5 1/16	5 1/16	5 13/32	5 13/32	5 13/32	5 31/32	5 31/32	5 31/32	5 31/32	6 13/32

NAVY DEPARTMENT BUREAU OF SHIPS WASHINGTON D.C.

ELECTRIC PLANT INSTALLATION
STANDARD METHODS

MINIMUM SPACING OF HOLES FOR STUFFING TUBES AND KICKPIPES IN METAL DECKS AND BULKHEADS

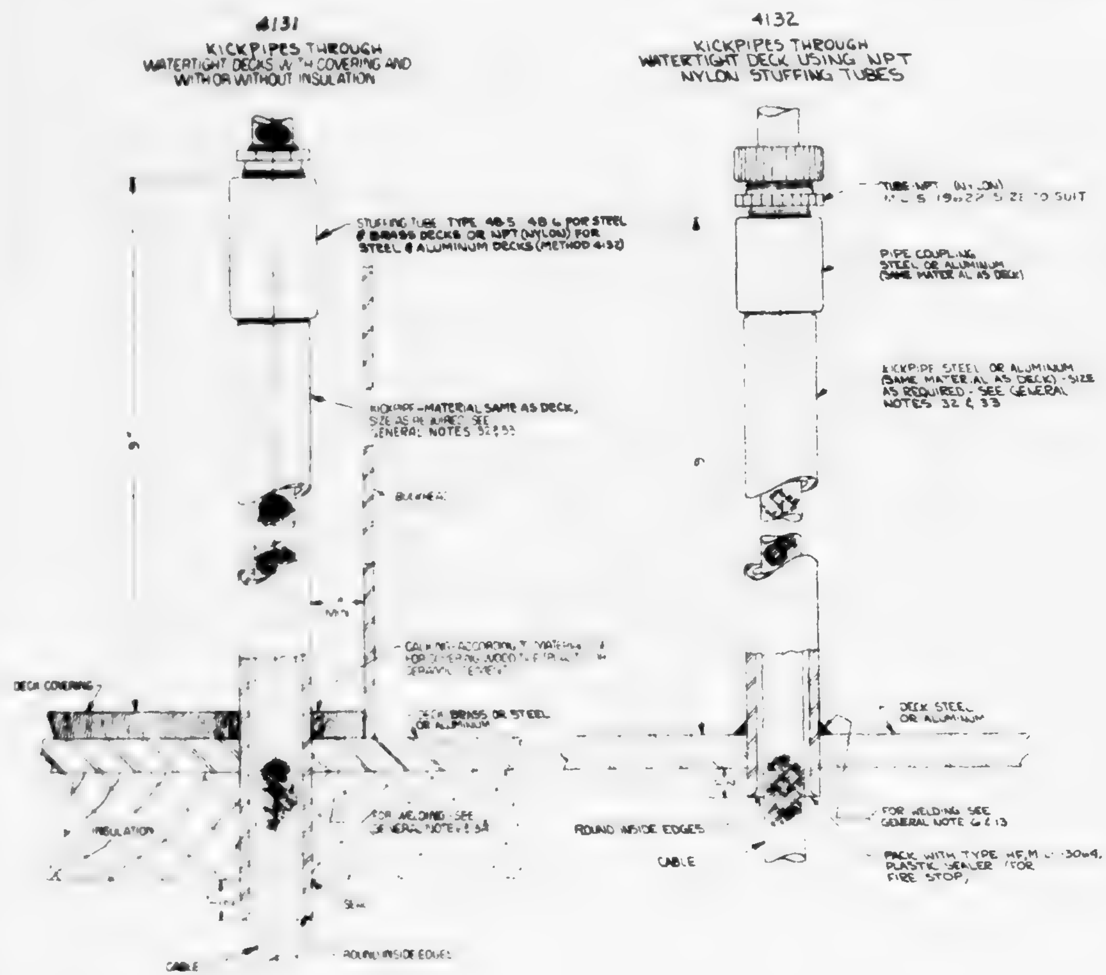
EXAMINED
OFFICIAL SIGNATURE

SECTION 4
SHEET 2

9000 | S6202 | 7398
SCALE-NONE

KICKPIPES THROUGH STEEL, BRASS OR ALUMINUM DECKS

STUFFING TUBE - MIL S 24235 & MIL S-19622



REVISIONS

REV	DESCRIPTION	DATE		
A	FIRST ISSUE			
B	REVISED WELDING REF			
C	EXTENDED APPLICABILITY TO ALUMINUM DECKS. ADDED METHOD 4132			
D	UPDATED SPEC			

NAVY DEPARTMENT WASHINGTON D.C.

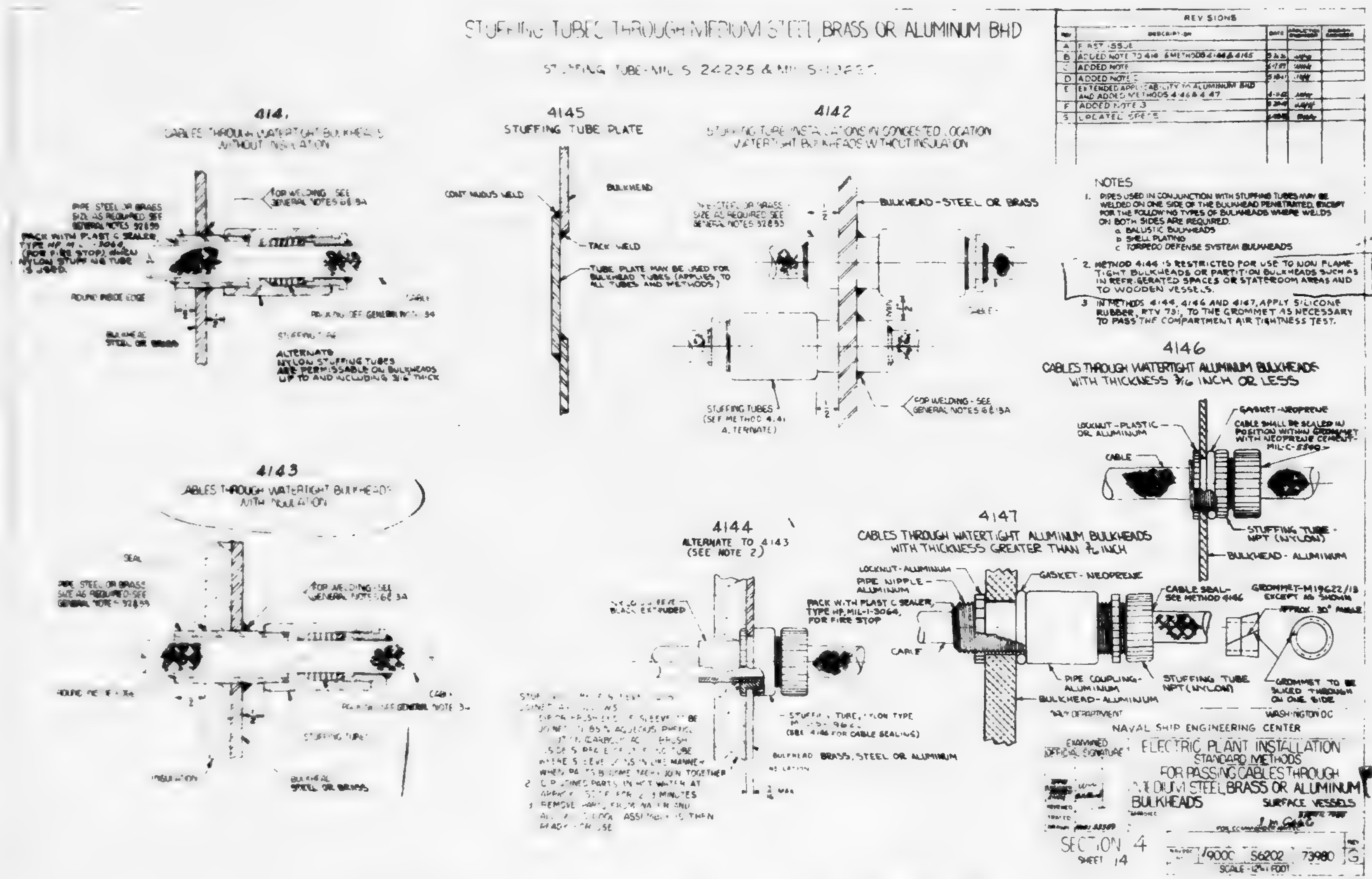
NAVAL SHIP ENGINEERING CENTER

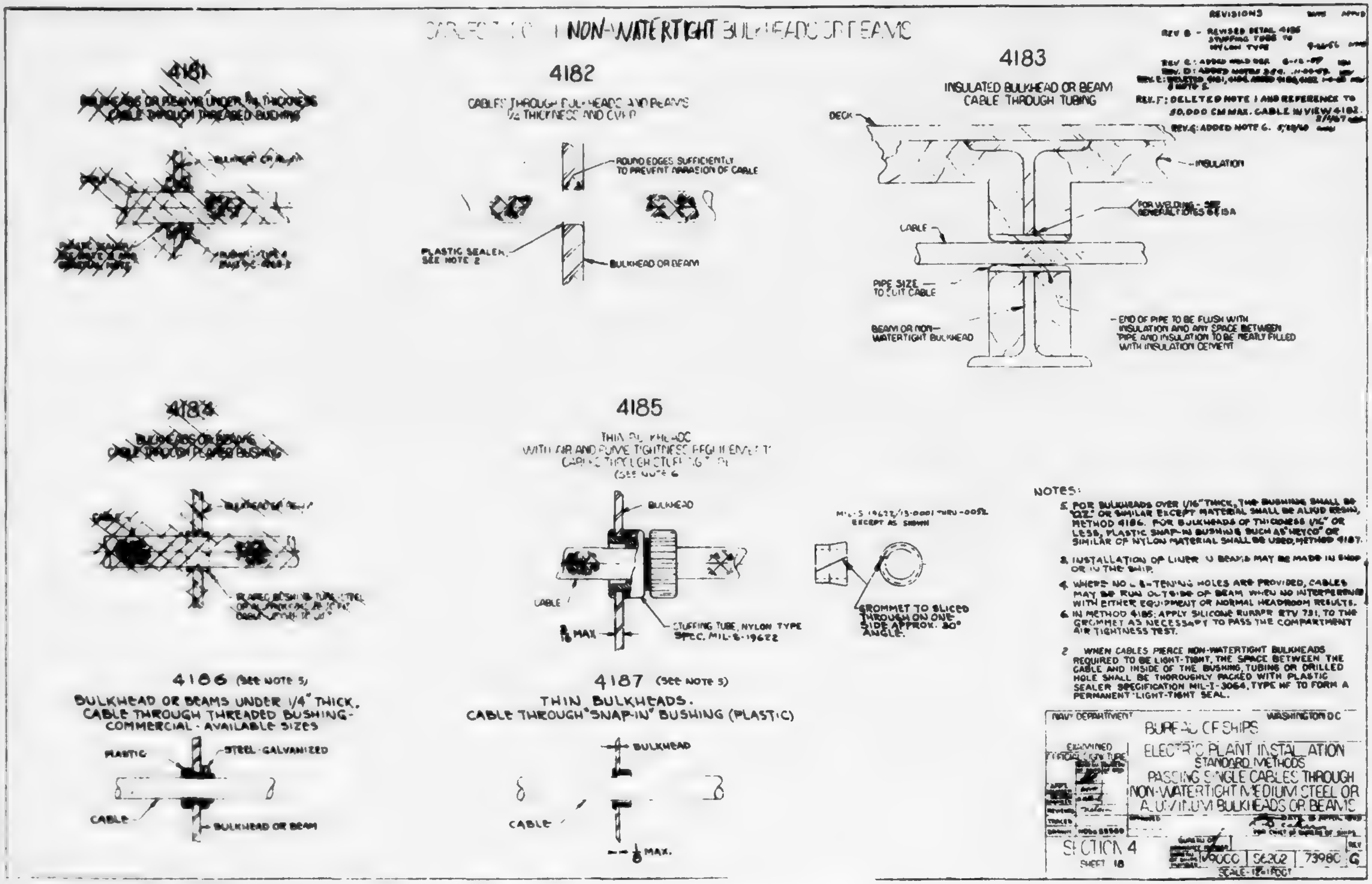
ELECTRIC PLANT INSTALLATION
STANDARD METHODS
FOR PASSING CABLES THROUGH
MEDIUM STEEL, BRASS OR ALUMINUM
DECKS SURFACE VESSELS

SECTION 4 SHEET 13

9000 | S6202 | 73980 | D

SCALE: 12" = 1 FOOT


STUFFING TUBES THROUGH MEDIUM STEEL, BRASS OR ALUMINUM BHD
4141
CABLES THROUGH WATERTIGHT BULKHEADS WITHOUT INSULATION
4145
STUFFING TUBE PLATE
CONTINUOUS WELD
BULKHEAD
TACK WELD
TUBE PLATE MAY BE USED FOR BULKHEAD TUBES (APPLIES TO ALL TUBES AND METHODS)
4142
BULKHEAD - STEEL OR BRASS
STUFFING TUBES
ALTERNATE NYLON STUFFING TUBES ARE PERMISSABLE ON BULKHEADS UP TO AND INCLUDING 3/16 THICK
4143
CABLES THROUGH WATERTIGHT BULKHEADS WITH INSULATION
4144
ALTERNATE TO 4143 (SEE NOTE 2)
4147
CABLES THROUGH WATERTIGHT ALUMINUM BULKHEADS WITH THICKNESS GREATER THAN 3/16 INCH
4146
CABLES THROUGH WATERTIGHT ALUMINUM BULKHEADS WITH THICKNESS 3/16 INCH OR LESS
GASKET - NEOPRENE
STUFFING TUBE - NPT (NYLON)
BULKHEAD - ALUMINUM
CABLE
REVISIONS
A FIRST ISSUE
B ADDED NOTE TO 4141 & METHODS 4144 & 4145
C ADDED NOTE
D ADDED NOTE
E EXTENDED APPLICABILITY TO ALUMINUM BHD AND ADDED METHODS 4146 & 4147
F ADDED NOTE 3
G LOCATED SPEC
NOTES
1. PIPES USED IN CONJUNCTION WITH STUFFING TUBES MAY BE WELDED ON ONE SIDE OF THE BULKHEAD PENETRATED, EXCEPT FOR THE FOLLOWING TYPES OF BULKHEADS WHERE WELDS ON BOTH SIDES ARE REQUIRED.
a BALLISTIC BULKHEADS
b SHELL PLATING
c TORPEDO DEFENSE SYSTEM BULKHEADS
2. METHOD 4144 IS RESTRICTED FOR USE TO NON FLAME-TIGHT BULKHEADS OR PARTITION BULKHEADS SUCH AS IN REFRIGERATED SPACES OR STATEROOM AREAS AND TO WOODEN VESSELS.
3. IN METHODS 4144, 4146 AND 4147, APPLY SILICONE RUBBER, RTV 731, TO THE GROMMET AS NECESSARY TO PASS THE COMPARTMENT AIR TIGHTNESS TEST.
NAVAL SHIP ENGINEERING CENTER
WASHINGTON DC
ELECTRIC PLANT INSTALLATION
STANDARD METHODS
FOR PASSING CABLES THROUGH
MEDIUM STEEL, BRASS OR ALUMINUM BULKHEADS
SURFACE VESSELS
SECTION 4
SHEET 14
9000 S6202 73980 G

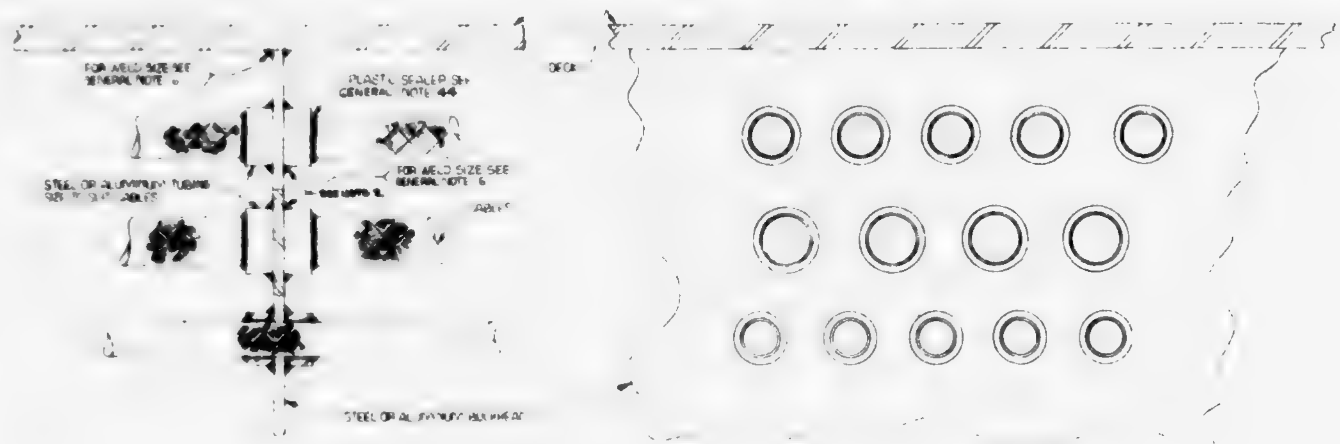

NON-WATERTIGHT
4181
4182
CABLES THROUGH BULKHEADS AND BEAMS 1/2 THICKNESS AND OVER
ROUND EDGES SUFFICIENTLY TO PREVENT ABRASION OF CABLE
PLASTIC SEALER. SEE NOTE 2
BULKHEAD OR BEAM
4183
INSULATED BULKHEAD OR BEAM CABLE THROUGH TUBING
DECK
INSULATION
CABLE
PIPE SIZE TO SUIT CABLE
BEAM OR NON-WATERTIGHT BULKHEAD
END OF PIPE TO BE FLUSH WITH INSULATION AND ANY SPACE BETWEEN PIPE AND INSULATION TO BE NEATLY FILLED WITH INSULATION CEMENT
REVISIONS
REV. F: DELETED NOTE 1 AND REFERENCE TO 50,000 CM MAX. CABLE IN VIEW 4182.
REV. G: ADDED NOTE 6.
4184
4185
BULKHEAD
CABLE
STUFFING TUBE, NYLON TYPE SPEC. MIL-S-19622
GROMMET TO SLICED THROUGH ON ONE SIDE APPROX. 30° ANGLE.
4186 (SEE NOTE 5)
BULKHEAD OR BEAMS UNDER 1/4" THICK. CABLE THROUGH THREADED BUSHING - COMMERCIAL - AVAILABLE SIZES
PLASTIC
STEEL-GALVANIZED
CABLE
BULKHEAD OR BEAM
4187 (SEE NOTE 5)
THIN BULKHEADS. CABLE THROUGH "SNAP-IN" BUSHING (PLASTIC)
BULKHEAD
CABLE
1/8 MAX.
NOTES:
5. FOR BULKHEADS OVER 1/16" THICK, THE BUSHING SHALL BE "QZ" OR SIMILAR EXCEPT MATERIAL SHALL BE ALKYD RESIN, METHOD 4186. FOR BULKHEADS OF THICKNESS 1/16" OR LESS, PLASTIC SNAP-IN BUSHING SUCH AS "HEYCO" OR SIMILAR OF NYLON MATERIAL SHALL BE USED, METHOD 4187.
3. INSTALLATION OF LINER U BEAMS MAY BE MADE IN SHOP OR IN THE SHIP.
4. WHERE NO LIGHTENING HOLES ARE PROVIDED, CABLES MAY BE RUN OUTSIDE OF BEAM WHEN NO INTERFERENCE WITH EITHER EQUIPMENT OR NORMAL HEADROOM RESULTS.
6. IN METHOD 4185: APPLY SILICONE RUBBER RTV 731, TO THE GROMMET AS NECESSARY TO PASS THE COMPARTMENT AIR TIGHTNESS TEST.
2. WHEN CABLES PIERCE NON-WATERTIGHT BULKHEADS REQUIRED TO BE LIGHT-TIGHT, THE SPACE BETWEEN THE CABLE AND INSIDE OF THE BUSHING, TUBING OR DRILLED HOLE SHALL BE THOROUGHLY PACKED WITH PLASTIC SEALER SPECIFICATION MIL-I-3064, TYPE HF TO FORM A PERMANENT LIGHT-TIGHT SEAL.
NAVY DEPARTMENT
WASHINGTON DC
BUREAU OF SHIPS
ELECTRIC PLANT INSTALLATION
STANDARD METHODS
PASSING SINGLE CABLES THROUGH NON-WATERTIGHT MEDIUM STEEL OR ALUMINUM BULKHEADS OR BEAMS
SECTION 4
SHEET 18
80064
56202
7398C
G

REV. B: ADDED NOTE 2.

CABLES THROUGH NON-WATERTIGHT BULKHEADS OR BEAMS

4201

MULTIPLE ROWS OF CABLES THROUGH BULKHEADS
WITH AIR AND FUME TIGHTNESS REQUIREMENTS
CABLES THROUGH TUBING



NOTE -

1. MINIMUM SPACING OF TUBES TO BE SUFFICIENT TO PERMIT SATISFACTORY WELDING

2. CHAFING NIPPLES USED TO PROTECT CABLES PASSING THRU BULKHEADS SHALL BE WELDED ON ONE SIDE OF THE BULKHEAD PENETRATED, EXCEPT FOR THE FOLLOWING TYPES OF BULKHEADS WHERE WELDS ON BOTH SIDES ARE REQUIRED:
   a. BALLISTIC BULKHEADS
   b. SHELL PLATING.
   c. TORPEDO DEFENSE BULKHEADS.

NAVY DEPARTMENT WASHINGTON DC

BUREAU OF SHIPS

ELECTRIC PLANT INSTALLATION
STANDARD METHODS
PASSING MULTIPLE CABLES
THROUGH NON-WATERTIGHT
BULKHEADS AND BEAMS

EXAMINED
OFFICIAL SIGNATURE

SECTION 4
SHEET 20

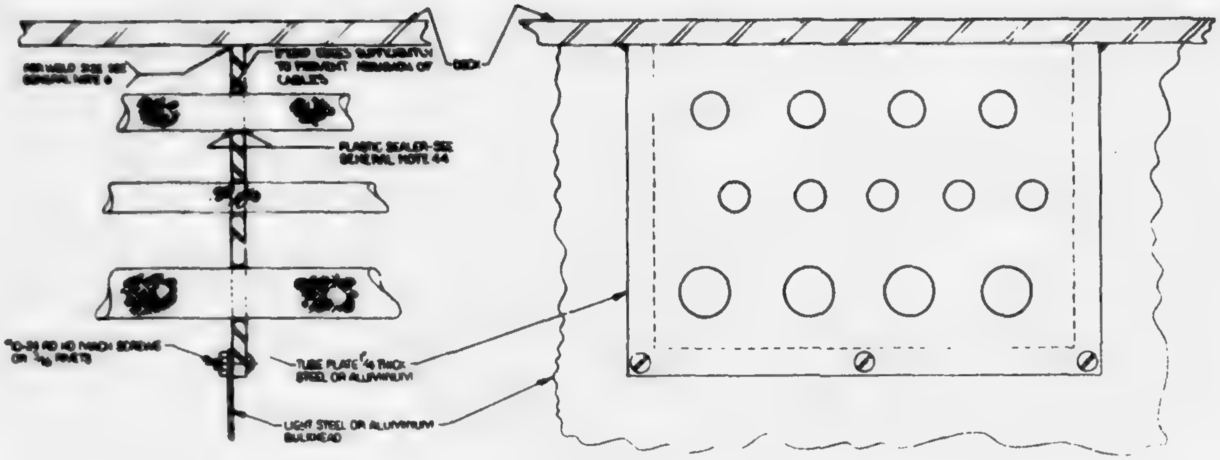
	9000	S6202	73980	B

SCALE 12"=1 FOOT

CABLES THROUGH NON-WATERTIGHT BULKHEADS OR BEAMS

4211

MULTIPLE ROWS OF CABLES THROUGH LIGHT BULKHEAD
WITH AIR AND FUME TIGHTNESS REQUIREMENTS



NOTE -
1 MINIMUM SPACING OF TUBES TO BE SUFFICIENT TO PERMIT SATISFACTORY WELDING

NAVY DEPARTMENT — BUREAU OF SHIPS — WASHINGTON D.C.

ELECTRIC PLANT INSTALLATION
STANDARD METHODS
PASSING MULTIPLE CABLES
THROUGH NON-WATERTIGHT
BULKHEADS AND BEAMS

SECTION 4
SHEET 21

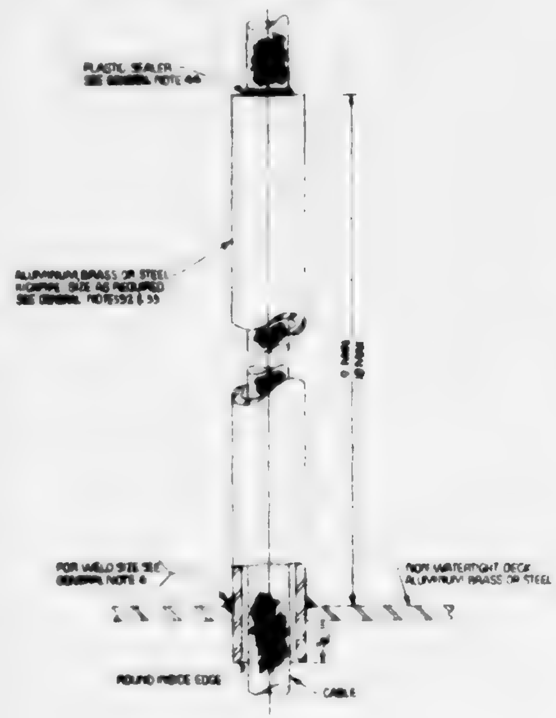
9000	S6202	79980	D

REV. B: DELETED CONDUIT BUSHING 6-10-57

CABLES THROUGH NONTIGHT DECKS

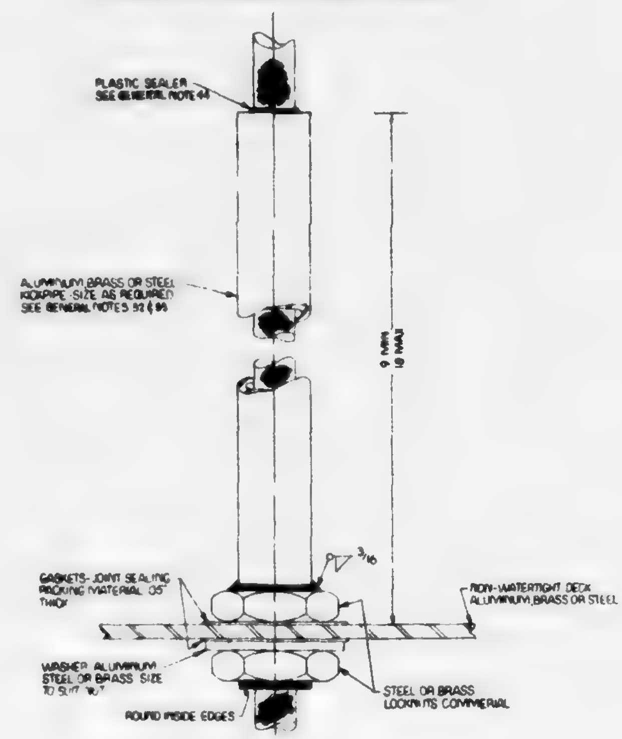
4261

ONE OR TWO SINGLE CABLES
THROUGH NONTIGHT DECKS
WITH KICKPIPE WELDED IN PLACE



4262

ONE OR TWO SINGLE CABLES
THROUGH NONTIGHT DECKS
WITH KICKPIPE SECURED WITH LOCKNUTS
APPLICABLE IN LOCATIONS INACCESSIBLE FOR WELDING



NAVY DEPARTMENT — BUREAU OF SHIPS — WASHINGTON D.C.

EXAMINED / OFFICIAL SIGNATURE

ELECTRIC PLANT INSTALLATION
STANDARD METHODS

FOR PASSING SINGLE CABLES THROUGH NONTIGHT ALUMINUM, BRASS OR MEDIUM STEEL DECKS
(SURFACE VESSELS)

SECTION 4
SHEET 26

9000	S6202	73980	B

SCALE - 12"=1 FOOT

NOMENCLATURE

MULTI CABLE TRANSIT
A SYSTEM OF PASSING CABLES THRU WATER AND NON WATER TIGHT BULKHEADS AND DECKS DESIGNED TO SUIT PARTICULAR BULKHEAD AND DECK WEIGHTS

NOMENCLATURE
THROUGHOUT THIS STANDARD OF ELECTRIC PLANT INSTALLATION DRAWINGS THE FOLLOWING SHALL PREVAIL

(A) FRAMES, UNBANDED
(a1) CONSISTS OF THREE BASIC SIZES 2, 4 AND 6. ALL ARE 5.906 WIDE. SIZE 2 IS 4.736 HIGH, SIZE 4 IS 7.090 HIGH AND SIZE 6 IS 9.537 HIGH
(a2) MATERIAL SHALL BE EITHER STEEL OR ALUMINUM. 1/4 OR 3/8 THICK (DEPENDING ON WEIGHT OF BULKHEAD OR DECK) IN STEEL OR 1/2 THICK IN ALUMINUM. ALL ARE 2 5/8 WIDE
(a3) THERE ARE FOUR DIFFERENT TYPE FRAMES
RGS - STEEL FOUR CORNERS WELDED (COMPLETELY CLOSED)
RGSO STEEL TWO CORNERS WELDED (OPEN BOTTOM)
RGA - ALUMINUM FOUR CORNERS WELDED (COMPLETELY CLOSED)
RGAO ALUMINUM TWO CORNERS WELDED (OPEN BOTTOM)
(a4) TO RECAP SUB PARAGRAPHS (a1) THRU (a3) AN UNBANDED FRAME IS IDENTIFIED AS FOLLOWS AN RGS 2 x 3/8 IS A 3/8 THICK SIZE 2 STEEL FRAME WITH FOUR CORNERS WELDED (COMPLETELY CLOSED)

(B) FRAMES, BANDED
(b1) CONSISTS OF THREE BASIC SIZES SUB PARAGRAPH (a1) EACH OF WHICH IS ENCLOSED BY A REINFORCING BAND OF PROPER SIZE MATERIAL TO SUIT PARTICULAR BULKHEAD WEIGHT IN ADDITION TO THE BAND FILLER PLATES ARE EMPLOYED TO SEAL EMPTY SPACES BETWEEN FRAME AND BAND
(b2) RGS AND RGA BANDED FRAMES ARE COMPLETE UNITS READY TO BE INSTALLED IN BULKHEAD
RGSO AND RGAO BANDED FRAMES HAVE LOWER HALF OF BAND AND FRAME TEMPORARILY TACK WELDED. AT INSTALLATION THIS TACK WELD IS BROKEN, FRAME IS WRAPPED AROUND CABLES, AND ALL WELDING IS COMPLETED

(C) PHYSICAL ARRANGEMENT AND IDENTIFICATION
(c1) VARIOUS ARRANGEMENTS OF FRAMES ARE AVAILABLE IN ALL SIZES AND TYPES EXAMPLES AND DIMENSIONS ARE SHOWN ON SHEETS 176, 177 & 178
(c2) IDENTIFICATION OF VARIOUS ARRANGEMENTS ARE MADE BY THE FOLLOWING EXAMPLES

RGS 2 x 3 3/8 THICK — TYPE, SIZE, NUMBER OF OPENINGS, MAT'L
RGS 2 x 3(T) 3/8 THICK — TYPE, SIZE, NUMBER OF OPENINGS IN TANDEM, MAT'L

SINGLE OR DOUBLE WALL BANDED OR UNBANDED MUST BE SPECIFIED

(D) COMPRESSION BOLT
(d1) STAINLESS STEEL, 5/8-10 THREAD WHEN TIGHTENED SEATS THE COMPRESSION PLATE FARTHER DOWN INTO THE TRANSIT FRAME

(E) PLUG
(e1) STAINLESS STEEL 5/8-10 THREAD USED TO PLUG TAPPED HOLE IN FRAME OPPOSITE COMPRESSION BOLT

(F) STAY PLATE
(f1) EITHER STEEL OR ALUMINUM NORMALLY PLACED BETWEEN EVERY OTHER ROW OF INSERT BLOCKS KEEPING THEM POSITIONED IN THE TRANSIT FRAME

(G) COMPRESSION PLATE
(g1) EITHER CAST IRON OR CAST ALUMINUM, SEATS AND COMPRESSES THE INSERT BLOCKS SO THAT THE ENDPACKING CAN BE INSERTED IN THE TRANSIT FRAME

(H) END PACKING, STANDARD
(h1) COMPRESSES THE INSERT BLOCKS USED WHEN FRAME CAN BE PACKED FROM EITHER SIDE
(h2) ASSEMBLY WHICH CONSISTS OF TWO NEOPRENE ELASTOMER BLOCKS AND TWO END PACKING WASHERS HELD TOGETHER BY TWO 5/16 BOLTS AND HEX NUTS WASHERS, NUTS AND BOLTS ARE STEEL CADMIUM PLATED. FOR NON MAGNETIC APPLICATIONS STAINLESS STEEL IS USED

(J) END PACKING, SPECIAL
(j1) COMPRESSES THE INSERT BLOCKS USED WHEN FRAME CAN ONLY BE PACKED FROM ONE SIDE
(j2) ASSEMBLY WHICH CONSISTS OF FOUR NEOPRENE ELASTOMER PIECES, ONE END PACKING WASHER, TWO END PACKING WASHERS SPECIAL AND TWO 5/16 HEX NUTS. ALL ARE STEEL CADMIUM PLATED. FOR NON-MAGNETIC APPLICATIONS STAINLESS STEEL IS USED

(K) INSERT BLOCKS
(k1) TWIN HALF BLOCKS ARE SPECIALLY FORMULATED OF A NEOPRENE ELASTOMER WITH A CENTERED SEMI CIRCULAR GROOVE. WHEN MATCHED AROUND A CABLE THESE BLOCKS FORM A SINGLE BLOCK WITH A TIGHT FIT. BASIC SIZES ARE SHOWN ON SHEET 171

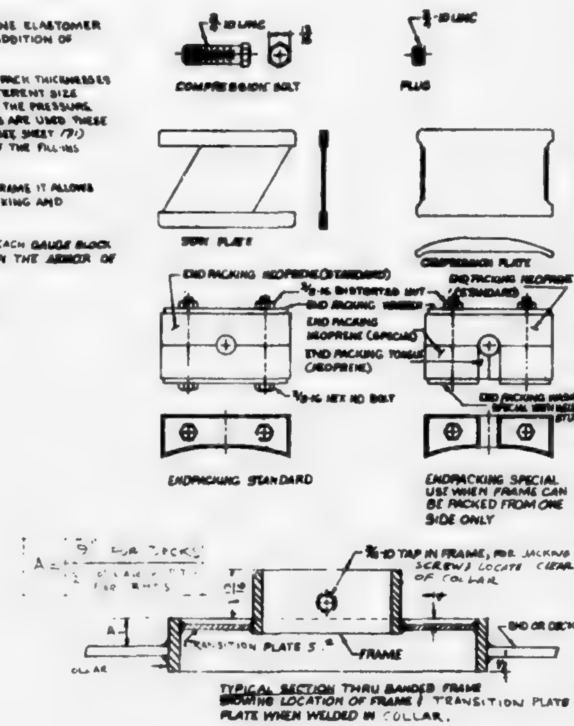
(L) SPARES
(l1) SOLID BLOCKS ARE SPECIALLY FORMULATED OF A NEOPRENE ELASTOMER AND ARE USED AS FILLERS OR SPARE PROVISIONS FOR ADDITION OF FUTURE CABLES. SIZES ARE SHOWN ON SHEET 171

(M) FILL INS
(m1) SAME MATERIAL AS INSERT BLOCKS AND SPARES. USED TO PACK THICKNESSES OF 5 OR 10 MILLIMETERS CAUSED BY THE PRESENCE OF DIFFERENT SIZE BLOCKS IN THE SAME ROW. ALSO EMPLOYED TO INCREASE THE PRESSURE IN THE TRANSIT FRAME WHEN EXCEPTIONALLY SOFT CABLES ARE USED. THESE FILL INS ARE AVAILABLE IN TWO SIZES 24 x 5/16 OR 12 x 5/16 (SEE SHEET 171). SERRATIONS HAVE BEEN PROVIDED TO PERMIT SLICING OF THE FILL-INS TO THE REQUIRED LENGTH. EXAMPLE 6 x 5/16, 8 x 5/16 ETC

(N) TALLOW
(n1) INSERT BLOCK LUBRICANT USED WHEN PACKING TRANSIT FRAME. IT ALLOWS THE BLOCKS TO SLIDE EASILY OVER EACH OTHER WHEN PACKING AND COMPRESSING THEM AROUND CABLES

(P) SEALER
(p1) LIQUID SILICONE RUBBER APPLIED TO CABLE SIDE OF EACH GAUGE BLOCK UPON COMPRESSION. THIS PROVIDES A SEAL BETWEEN THE ARMOR OF THE CABLE AND IT'S IMPERVIOUS INNER SHEATH

(Q) DISTORTED NUT
(q1) ALL NUTS ARE TO BE IN ACCORDANCE WITH MIL-N-25027C MATERIAL CRS PER MIL-S-857



NAVY DEPARTMENT	WASHINGTON D.C.
NAVAL SHIP ENGINEERING CENTER	
EXAMINED	ELECTRIC PLANT INSTALLATION STANDARD METHODS NOMENCLATURE FOR MULTI-CABLE TRANSIT
SECTION 4 SHEET 170	9000 S6202 73980 B

Copy available to DDC does not permit fully legible reproduction

TABLE NO 2 CABLE INFORMATION AND ASSIGNMENT FOR MULTI CABLE TRANSIT INSERT BLOCKS

CABLE TYPE	DIAMETER IN INCHES	DIAMETER IN MM	INSERT BLOCK	INSERT BLOCK
[illegible]-9	0.570	14.48	20/14	30/14
[illegible]-14	0.705	17.91	30/17	
[illegible]-23	0.[illegible]	[illegible]	30/[illegible]	
[illegible]-30	0.9[illegible]	[illegible]	30/[illegible]	40/[illegible]
[illegible]-83	1.4[illegible]	36.83	60/36	
[illegible]-250	[illegible].100	53.[illegible]	60/58	
[illegible]-400	[illegible].500	63.50	90/60	
[illegible]-3	0.450	11.43	[illegible]/11	
[illegible]-4	0.480	12.19	20/12	30/12
[illegible]-6	0.550	13.97	[illegible]/13	30/13
[illegible]-9	0.600	15.[illegible]	30/15	
[illegible]-14	0.750	19.05	30/19	
[illegible]-23	0.900	[illegible]	30/[illegible]	40/[illegible]
[illegible]-42	1.[illegible]	31.75	60/30	
[illegible]-150	1.[illegible]	46.[illegible]	60/[illegible]	
[illegible]-250	2.[illegible]	[illegible].90	90/[illegible]	
[illegible]-400	2.[illegible]	[illegible].1[illegible]	90/7[illegible]	
[illegible]-3	0.480	12.19	20/12	30/12
[illegible]-4	0.550	13.97	[illegible]/13	30/13
[illegible]-9	0.660	16.76	30/16	
[illegible]-133	[illegible].000	50.80	60/50	90/50
[illegible]-3	0.460	11.[illegible]	20/11	
[illegible]-4	0.580	13.[illegible]	[illegible]/13	30/13
[illegible]-7	0.6[illegible]	15.93	30/15	
[illegible]-1[illegible]	0.7[illegible]	[illegible]	30/[illegible]	
[illegible]-14	0.8[illegible]	[illegible]	30/[illegible]	
[illegible]-19	0.995	[illegible]	30/[illegible]	40/[illegible]
[illegible]-[illegible]	1.180	[illegible].05	40/[illegible]	
[illegible]-30	1.194	30.33	40/30	
[illegible]-37	1.290	32.77	40/[illegible]	60/30
[illegible]-44	1.4[illegible]	[illegible].07	60/[illegible]	
[illegible]-14	0.450	11.43	[illegible]/11	
[illegible]-37	0.800	[illegible]	30/[illegible]	
DCOP-1	0.250	[illegible]	15/[illegible]	[illegible]
DCOP-1 1/2	0.315	8.00	15/[illegible]	[illegible]
DCOP-2	0.330	[illegible]	15/[illegible]	[illegible]
TCOP-[illegible]	0.[illegible]	[illegible].77	15/[illegible]	[illegible]
TCOP-[illegible]	1.[illegible]	31.75	[illegible]/30	
TTOP-3	0.[illegible]	[illegible]	[illegible]	[illegible]
TTOP-5	0.590	14.99	[illegible]	[illegible]
TTOP-10	[illegible].700	17.78	30/17	
TTOP-15	0.830	21.08	30/21	
[illegible]-19(5)	1.[illegible]	[illegible]	60/[illegible]	[illegible]
[illegible]-19(10)	1.5[illegible]	[illegible].51	60/[illegible]	
[illegible]-19(2)	1.[illegible]	[illegible]	60/[illegible]	
[illegible]-19(40)	2.100	53.[illegible]	60/5[illegible]	
[illegible]	1.[illegible]	[illegible]	[illegible]	
[illegible]-2	0.390	9.91	15/[illegible]	[illegible]
[illegible]-4	0.500	12.70	20/12	[illegible]
[illegible]-5	0.500	12.[illegible]	[illegible]/12	[illegible]

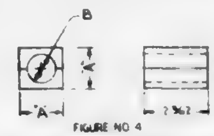


FIGURE NO 4

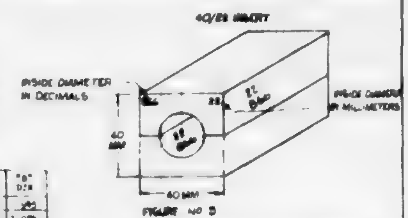


FIGURE NO 5

TYPICAL INSERT BLOCK IDENTIFICATION

THBA 30 CABLE HAS AN OUTSIDE DIAMETER OF 0.902 SELECT INSERT BLOCKS CONTAINING THE NEXT INSIDE DIAMETER THAT IS LESS THAN THE OUTSIDE DIAMETER OF THE CABLE A 22 MM HOLE IS 0.866 AND WILL PROVIDE THE FOLLOWING PRIOR TO COMPRESSION

FIGURE NO 6

NAVAL SHIP ENGINEERING CENTER

ELECTRIC PLANT INSTALLATION

STANDARD METHODS

PREFORMED MODULES

FOR

MULTI-CABLE TRANSIT FRAME

SECTION 4

9000	S6202	73980	B

Copy available to DDC does not permit fully legible reproduction

NOTES

RGS AND RGA CABLE TRANSIT DEVICES

1 MULTI-CABLE TRANSIT IS A MODULAR SYSTEM THAT UTILIZES STANDARD UNITS AND DIMENSIONS TO ALLOW MAXIMUM FLEXIBILITY AND COMPATABILITY WITH VARIOUS NUMBERS AND SIZES OF CABLES. FINAL SEALED UNITS WILL PROVIDE WATERTIGHT, AIRTIGHT AND FIREPROOF BULKHEAD OR DECK PENETRATIONS.

2 PULL ALL CABLES THRU CABLE TRANSIT DEVICE BEARING IN MIND CABLE SHALL ALWAYS APPROACH DEVICE IN A HORIZONTAL PLANE PERPENDICULAR TO THE DEVICE. THIS CAN BE ACCOMPLISHED IF THE NEAREST CABLE HANGER IS 16" MINIMUM FROM BULKHEAD. CABLES RUNNING UP A BULKHEAD AND THRU A TRANSIT DEVICE MUST HAVE ITS FULL BENDING RADIUS OUTSIDE OF THE DEVICE. WHILE IN THE PROCESS OF PULLING CABLES IT IS IMPERATIVE THAT A REASONABLE AMOUNT OF SLACK SHOULD BE LEFT TO FACILITATE MOVEMENT OF CABLE WITHIN TRANSIT DEVICE TO EASE PACKING OPERATION. ALSO IT IS NECESSARY THAT EACH CABLE BE IDENTIFIED ON THE COMPRESSION BOLT SIDE OF CABLE TRANSIT DEVICE BY LEAD NUMBER AND CABLE SIZE. ALL CABLES THRU A NEW CABLE TRANSIT DEVICE SHALL BE PULLED PRIOR TO INSTALLING INSERT BLOCKS.

3 AFTER PULLING ALL CABLES THROUGH A PARTICULAR CABLE TRANSIT DEVICE IT CAN BE PACKED. FIRST APPLY A LIGHT COAT OF MULTI-CABLE TRANSIT LUBRICANT (TALLOW) TO ALL OUTSIDE SURFACES OF THE INSERT BLOCKS, THE INSIDE PORTION OF THE FRAME AND THE CURVED SURFACE OF THE COMPRESSION PLATE. WHEN PACKING ARMORED CABLE, APPLY GENERAL ELECTRICS RTV-112 SEALER ON THE SURFACE OF EACH BLOCK THAT CONTACTS THE CABLE (A 1/8" BEAD EVERY 1/2" AROUND THE CIRCUMFERENCE). EACH FRAME MUST BE LAID OUT (BLOCKED) SHOWING SOLID BLOCKS (USED AS SPARES) AND CABLE ASSIGNMENTS PRIOR TO PACKING. A TYPICAL EXAMPLE OF A PACKED RGS-4 FRAME WITH INSTRUCTIONS FOR PACKING IS SHOWN BELOW (SCALE 3/4)

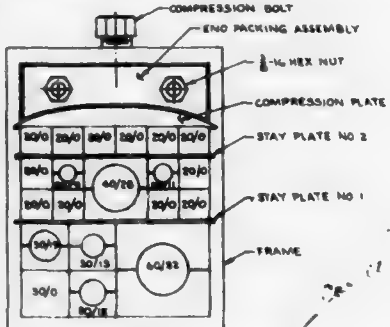


FIGURE NO 7

(A) SELECT INSERT BLOCKS AND SPARES FROM SHEET 161 AND PREPARE AS ABOVE (LUBRICANT AND SEALER WHERE REQUIRED)

(B) STARTING WITH THE HEAVIEST CABLE PLACE THE LOWER HALF OF THE 60/32 INSERT BLOCK UNDER THE CABLE IN THE FRAME. NEXT REPEAT THE PROCEDURE WITH THE 30/15 THEN ADD ONE 30/0 SPARE. ADD THE UPPER HALF OF THE 60/32 AND THE 30/15 PLACE LOWER HALF OF 30/13 AND 30/9 UNDER CABLE THEN ADD UPPER HALVES, ACROSS THE TOP OF THESE ADD STAY PLATE NO 1

(C) ON TOP OF THE STAY PLATE PLACE FOUR 20/0 SPARES AND THE LOWER HALF OF THE 40/28 UNDER ITS CABLE. IN THE NEXT HIGHER ROW PLACE TWO 20/0 SPARES AND THE LOWER HALF OF 20/9 AND 20/11 UNDER THEIR RESPECTIVE CABLES THEN ADD UPPER HALVES OF 40/28, 20/11 AND 20/9 ON TOP OF THESE ADD STAY PLATE NO. 2

(D) ADD COMPRESSION PLATE TO THE FRAME

(E) LIFT COMPRESSION PLATE CLEAR OF STAY PLATE NO. 2 ADD FINAL ROW OF SIX 20/0 SPARES LOWER COMPRESSION PLATE TO THIS LEVEL

(F) TIGHTEN COMPRESSION BOLT DOWN ON COMPRESSION PLATE TO COMPRESS ENTIRE CONTENTS OF FRAME AND PROVIDE JUST ENOUGH CLEARANCE TO INSERT END PACKING ASSEMBLY. APPLY A GENEROUS AMOUNT OF LUBRICANT TO THIS CAVITY TO ASSIST INSERTION OF END PACKING

(G) DISASSEMBLE END PACKING ASSEMBLY AND INSTALL IN FRAME AROUND THE COMPRESSION BOLT. REASSEMBLE AND TIGHTEN 5/8-16 HEX NUTS EVENLY UNTIL END PACKING INSERT MATERIAL EXPANDS IN THE CAVITY AND THERE IS A SLIGHT ROLL OF THE MATERIAL AROUND THE END PACKING METAL WASHERS. BACK OFF COMPRESSION BOLT APPROX 1/8 OF A TURN, PACKING IS NOW COMPLETE

4 WHEN A MULTI-CABLE TRANSIT FRAME IS INSTALLED IN A STRUCTURE IN SUCH A MANNER THAT THE COMPRESSION BOLT IS LOCATED ON THE BOTTOM PACKING PROCEDURE IS THE SAME EXCEPT

(A) THE COMPRESSION PLATE IS INSTALLED FIRST

(B) THE FRAME IS PACKED FROM THE BOTTOM UP WITH THE SMALLEST CABLES BEING PACKED FIRST

5 TO ADD A NEW CABLE TO A PACKED FRAME LOOSEN THE 5/8-16 HEX NUTS AND REMOVE THE END PACKING METAL WASHERS, TIGHTEN THE COMPRESSION BOLT UNTIL END PACKING INSERT MATERIAL IS LOOSE, REMOVE INSERT MATERIAL FROM FRAME. LOOSEN COMPRESSION BOLT AND LIFT COMPRESSION PLATE CLEAR OF TOP SIX 20/0 SPARES. REMOVE THESE INSERTS REMOVE COMPRESSION PLATE AND FULL ACCESS TO THE INSERT BLOCKS AND CABLE IS AVAILABLE

6 TEMPLATE ALL WORK FROM SHIP

7 ALL WELDING AND INSPECTION TO BE IN ACCORDANCE WITH NAVSHIPS 0900-000-1000

8 ALL PAINTING TO BE DONE IN ACCORDANCE WITH PLAN-TYPE-S08-2488804

9 THE STRUCTURAL REINFORCEMENT SHOWN ON THIS PLAN DOES NOT APPLY TO FLIGHT DECK BENTS, FLIGHT DECK SUPPORT STRUCTURES OR OTHER SIMILAR TYPE STRUCTURE ON OTHER SHIPS. SUCH CASES MUST BE INDIVIDUALLY RESOLVED WITH STRUCTURAL DESIGN

10 MATERIAL OF F.B. REINFORCEMENT IS TO BE SIMILAR TO MATERIAL OF BHD, DECK OR RISER BOX PENETRATED

11 THIS PLAN WAS DEVELOPED FROM DESIGN DATA SHEET DDS 9110-1, REINFORCEMENT OF OPENINGS IN STRUCTURE OF SURFACE SHIPS OTHER THAN IN PROTECTIVE PLATING, TO PERMIT INSTALLATION OF MULTI-CABLE TRANSIT FRAME (TECHNA PRODUCTS OF NELSON ELECTRIC) IN WATERTIGHT DECKS AND BHDS OF SURFACE SHIPS.

12 FILLET WELD REINFORCEMENT FOR TBVI WELD JOINT SHALL BE 1/8" FOR RATING UP TO 15.3" AND 1/4" FOR RATING ABOVE 1765"

13 THE BHDS AND DECKS WHICH ARE CONSIDERED TO BE LONGITUDINAL STRENGTH MEMBERS ARE DEFINED IN NAVSHIPS DESIGN DATA SHEET DDS 9110-1 AS COMPONENTS IN "STRENGTH ENVELOPE" (I.E., IN OUTSIDE PLATING, UPPERMOST STRENGTH DECK, INNER BOTTOM, AND THEIR ASSOCIATED LONG'L FRAMING), AND FOR OTHER STRENGTH DECKS WITHIN THE MIDSHIP THREE-FIFTHS LENGTH" IF THERE IS DIFFICULTY IN DEFINITION CONSULT WITH STRUCTURAL DESIGN

14 CARE SHOULD BE TAKEN, WHILE INSTALLING CABLE TRANSIT DEVICE, TO INSURE THAT ALL OF ITS COAMING PROTUDES THRU BHD SUFFICIENTLY TO WELD IN PLACE

15 IT IS MANDATORY TO MAINTAIN A MINIMUM OF 1/2" FROM BHD TO BOLT HOLE CENTER FOR WRENCH CLEARANCE. ALSO LEAVE 4" CLEARANCE TO ALLOW FOR INSTALLATION OF COMPRESSION BOLT (FROM BOLT HOLE SIDE OF C.T.D. TO TO ANY STRUCTURE)

16 RISER BOX TO BE ATTACHED TO BHD OF 765" RT OR HEAVIER. IF BHD IS LESS THAN 765" RT ADJACENT TO RISER BOX INSTALLATION, INSTALL A BACK PLATE OF 10.5" RT BETWEEN THE BACK OF THE RISER BOX AND THE BHD

17 AFTER INSTALLATION IS COMPLETE ENTIRE DEVICE MAY BE PAINTED TO SUIT SURROUNDING STRUCTURE IN ACCORDANCE WITH THE GENERAL SPECIFICATIONS FOR BUILDING SHIPS FOR THE U.S. NAVY

INSTALLATION PROCEDURES FOR RGSO AND RGAO CABLE TRANSIT DEVICES

18 TEMPORARILY INSULATE CABLES FOR PROTECTION AGAINST WELDING AND BURNING

19 REMOVE OLD NON-WATERTIGHT STRUCTURE

20 PREPARE HOLE IN BULKHEAD TO RECEIVE MULTI-CABLE TRANSIT FRAME (DESIGNATED "RGSO") PICTURE SHOWS EXTERNAL BANDING. THIS IS USED ONLY WHEN REQUIRED

21 BOTTOM OF "RGSO" UNIT IS TACK WELDED TO OTHER THREE SIDES. REMOVE THIS PIECE.

22 SEGREGATE AND CONFINE REQUIRED CABLES WITHIN EACH THREE SIDED FRAME

23 WRAP WET ASBESTOS SHEETS AROUND CABLE, REPLACE BOTTOM PIECE AND CONTINUOUSLY WELD CORNERS. GRIND SMOOTH SAME AS TOP CORNERS

24 SLIDE UNIT INTO PREPARED HOLE IN BULKHEAD POSITION SO THAT CENTER LINE OF TAPPED HOLE IS 3/4" OUT FROM FACE OF BULKHEAD TO PERMIT CLEARANCE FOR THE COMPRESSION SCREW

25 WELD FRAME TO BULKHEAD WITH CONTINUOUS WELD ALL AROUND FRAME ON BOTH SIDES OF BULKHEAD

26 PROCEED AS OUTLINED IN NOTE 3

NAVY DEPARTMENT	WASHINGTON D.C.
NAVAL SHIP ENGINEERING CENTER	
EXAMINED	ELECTRIC PLANT INSTALLATION STANDARD METHODS NOTES FOR MULTI CABLE TRANSITS
SECTION 4 SHEET 172	APPROVED
NAVSEC NO.	9000 56202 73980 A

Copy available to DDC does not permit fully legible reproduction

MULTI-CABLE TRANSIT FRAME IN BULKHEADS

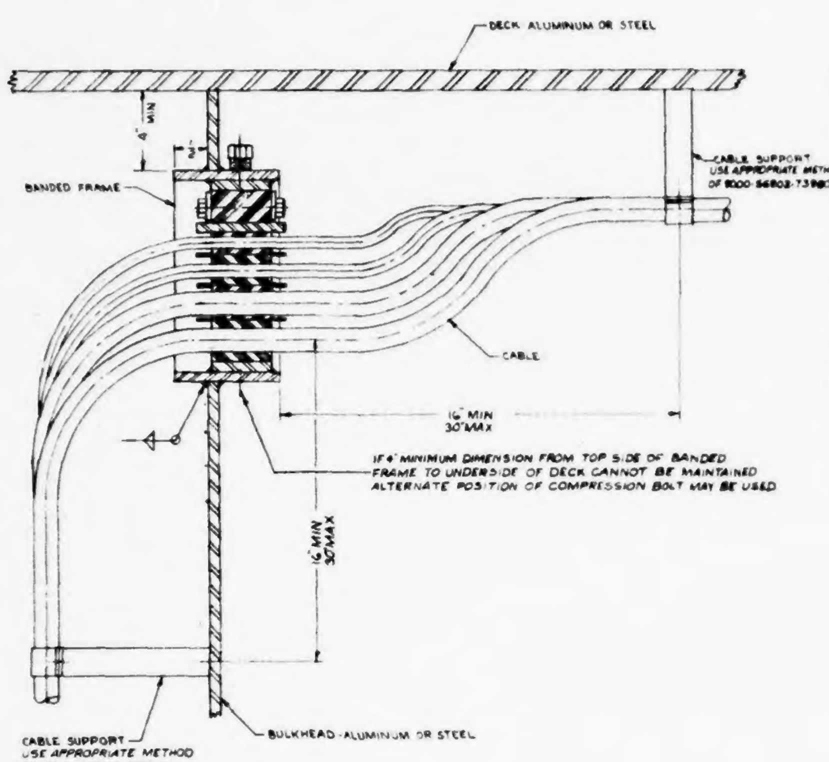


FIGURE NO 8

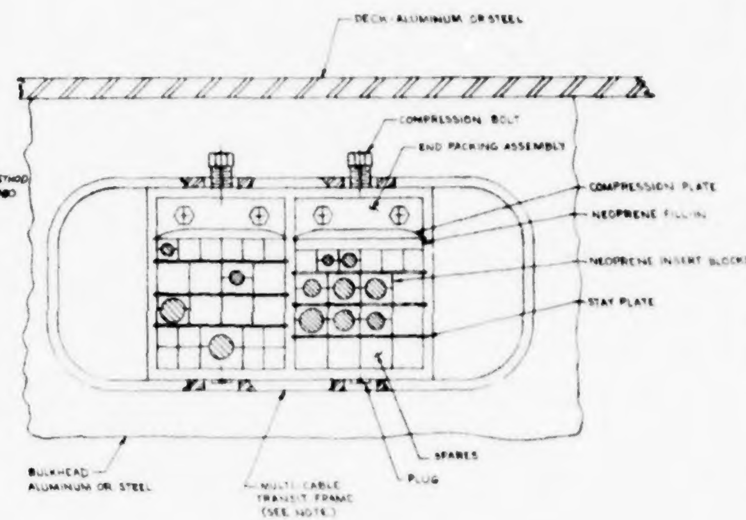


FIGURE NO 9

NOTE:
MULTI CABLE TRANSIT FRAMES ARE AVAILABLE IN VARIOUS SIZES AND ARRANGEMENTS. SHOWN IS A TWO FRAME TRANSIT

NAVY DEPARTMENT WASHINGTON D.C.
NAVAL SHIP ENGINEERING CENTER
ELECTRIC PLANT INSTALLATION
STANDARD METHODS FOR PASSING CABLES THROUGH BULKHEADS USING MULTI-CABLE TRANSIT FRAME
SECTION 4 SHEET 173
9000 S6202 73980 A

GENERAL NOTES

FOR BUREAU OF SHIPS DRAWING
9000-S6202-73980

REVISIONS

REV		
B	[illegible] NOTES 14A,B, 14, [illegible]	
	[illegible] NOTES 2,8A,& 8/A; WAS SHEET "K"	[illegible]
C	REVISED NOTES 33,36 [illegible]	[illegible]
D	REVISED NOTE 35	9-9-[illegible]
E	ADDED NOTE 28B	[illegible]
F	NOTES 20 & 22 THRU 28 REVISED AND SHOWN ON SHEET "K", NOTES [illegible] 27 DELETED. NOTE 13A REVISED	[illegible]
G	REVISED NOTES 1,6,19,29 AND 30.	[illegible]

GENERAL -

1-THE ELECTRIC PLANT INSTALLATION GENERAL REQUIREMENTS, SHALL BE IN ACCORDANCE WITH FUNCTIONAL ARRANGEMENT AS SHOWN HEREIN.

2-ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED ON THE INDIVIDUAL SHEETS.

3-THE TOLERANCES ON ALL DIMENSIONS GIVEN IN THIS DRAWING, UNLESS OTHERWISE SPECIFIED SHALL BE ±.005 INCHES FOR DECIMAL DIMENSIONS AND ±1/64 INCHES FOR FRACTIONAL DIMENSIONS.

4-HOLES DRILLED IN BEAMS FOR PASSING CABLES OR SECURING OF SUPPORTS OR EQUIPMENT SHALL BE LOCATED ON OR ABOVE THE NEUTRAL AXIS.

5-MALLEABLE IRON CASTINGS ARE NOT APPROVED FOR ANY INSTALLATION SHOWN ON THIS DRAWING EXCEPT AS NOTED.

WELDED ATTACHMENTS

6. "SEE SHEET G, NOTE 13"

6a- FOR PROCUREMENT APPLICATIONS ALL WELDING SHALL BE IN ACCORDANCE WITH THE REQUIREMENTS OF MIL-STD-278.

6b. COLLAR STUDS SHALL BE IN ACCORDANCE WITH SPEC MIL-S-16109.

~~[illegible]~~

13a-STUFFING TUBES, CHAFING NIPPLES & KICKPIPES DESIGNED TO BE INSTALLED IN A CLEARANCE HOLE & PASS COMPLETELY THROUGH DECKS & BULKHEADS SHALL IN GENERAL BE WELDED ON ONE SIDE OF THE DECK OR BULKHEAD, EXCEPT THAT IN THE FOLLOWING APPLICATIONS, THEY SHALL BE FILLET WELDED ON BOTH SIDES OF THE STRUCTURE:

(CONTINUED IN RIGHT COLUMN)

THREADED ATTACHMENTS

14-THREADS SHALL BE AMERICAN NATIONAL FORM, COARSE SERIES CLASS 2 UNLESS OTHERWISE SPECIFIED. THREAD FASTENINGS SHALL BE AS SPECIFIED IN NBS HANDBOOK H-28.

15-PADS, STUD PADS, ETC. SHALL BE TAPPED OR THREADED BEFORE BEING WELDED TO THE SHIPS STRUCTURE.

16-RIVETS BOLTS NUTS MACHINE SCREWS AND FLAT WASHERS SHALL BE OF THE BEST COMMERCIAL GRADE OF THE MATERIAL SPECIFIED.

17-IN LIEU OF THE HEX HEAD BOLTS SPECIFIED, ROUND HEAD MACHINE SCREWS OF THE SAME SIZE MAY BE USED.

MOUNTING CLEARANCES

18-ELECTRICAL CABLES, FIXTURES, PANELS, APPLIANCES, ETC. SHALL BE SECURED IN SUCH A MANNER THAT THEY DO NOT COME INTO DIRECT CONTACT WITH THE OUTER SHELL PLATING OF THE SHIP. A 2-INCH MINIMUM CLEARANCE SHALL BE MAINTAINED FOR INSPECTION AND PAINTING.

19-THE MOUNTING OF ELECTRICAL EQUIPMENT ON BULKHEADS SUBJECT TO CONDENSATION SUCH AS THE OUTER SURFACE OF REFRIGERATED SPACE BOUNDARY BULKHEADS SHALL BE AVOIDED. IF NO OTHER LOCATION IS FEASIBLE THE EQUIPMENT SHALL BE MOUNTED AT LEAST TWO INCHES CLEAR OF SUCH SURFACES. ALSO CABLE SHALL NOT BE MOUNTED IN DIRECT CONTACT WITH SUCH BULKHEADS, BUT SHALL USE ONE OF THE WET LOCATION METHODS. WHEN SUCH SURFACES ARE INSULATED, APPROPRIATE INSULATION METHODS SHALL BE USED FOR BOTH EQUIPMENT AND CABLE.

CABLE SUPPORTS (SEE SHEET "G")

~~[illegible]~~

~~[illegible]~~

EQUIPMENT MOUNTING

29-ELECTRIC DISTRIBUTION AND WIRING EQUIPMENT, FITTINGS AND APPLIANCES SHALL BE INSTALLED AS SHOWN HEREIN.

30-ELECTRICAL FIXTURES FOR LIGHTING SYSTEMS SHALL BE INSTALLED AS SHOWN IN SECT. 3 & 5 HEREIN AND IN LIGHTING ON NAVAL SHIPS NAVSHIPS 250-660-4.

31-WHERE CABLES ENTER FITTINGS AND FIXTURES A MINIMUM OF 2 INCHES OF SLACK CABLE SHALL BE PROVIDED IN THE CABLE RUN NEARBY TO PERMIT REPAIRS TO BE MADE AT THE CABLE ENDS WITH A VIEW OF AVOIDING CABLE RENEWALS. THIS SLACK IS NOT NECESSARY WHEN CABLES THE CONDUCTORS OF WHICH HAVE SLACK INSIDE THE ENCLOSURE. CABLES ENTERING ENCLOSURES SHALL BE SECURED TO BULKHEAD AS CLOSE TO ENCLOSURE AS PRACTICAL.

31a-BACKING PLATES ARE NOT REQUIRED FOR MOUNTING EQUIPMENT EXCEPT THAT WHEN BULKHEADS ARE 1/16" THICK OR LESS, BACKING WASHERS SHALL BE USED.

CABLE STUFFING TUBES AND BOX CONNECTORS

32-KICKPIPES, ALUMINUM, BRASS OR STEEL SHALL BE STANDARD PIPE SIZE.

33-ENDS OF PIPE SHALL BE CHAMFERED AND BURRS EXISTING ON THE INSIDE WALL SHALL BE REMOVED TO PREVENT CHAFING OF CABLE.

34-STUFFING TUBE PACKING SHALL BE IN ACCORDANCE WITH SPEC MIL-P-16685, EITHER THE PREFORMED (COIL) CLASS 2 OR BULK CLASS 1. WHEN BULK PACKING IS USED, THE FIRST AND LAST TURNS SHALL BE PART "A" (HARD) AND THE INTERMEDIATE TURNS SHALL BE PART "B" (SOFT) OF CLASS 1.

35-BOX CONNECTORS SHALL BE THE TYPE WITHOUT RETAINING LIPS AND WITHOUT ENLARGEMENT FOR CONDUIT OR "BX" ARMOR. "STRAIGHT DUPLEX" BOX CONNECTORS MAY BE USED FOR CABLE ENTRANCE, HOWEVER THE CABLES SHALL BE THE TYPE HAVING NYLON COVERED CONDUCTORS. DUPLEX CONNECTORS ARE NOT TO BE USED FOR CABLES HAVING WEAK SILICONE COVERED CONDUCTORS.

ALUMINUM STRUCTURE MOUNTING

36-ELECTRICAL FITTINGS HAVING BRASS ENCLOSURES WHEN INSTALLED ON ALUMINUM STRUCTURE, SHALL BE MOUNTED IN ACCORDANCE WITH METHODS SHOWN HEREIN TO PREVENT GALVANIC ACTION.

13a. WELDED ATTACHMENTS (CONTINUED FROM LEFT)

(1) BALLISTIC STRUCTURE
(2) TORPEDO DEFENSE SYSTEM BULKHEADS
(3) SHELL PLATING
(4) UPPERMOST STRENGTH DECK

THE CLEARANCE HOLE MAY BE CUT BY BURNING.

SEE NOTE 45A FOR TREATMENT OF CREVICES WHEN SINGLE FILLET WELDS ARE USED IN WET & HUMID AREAS.

STUFFING TUBES, CHAFING NIPPLES & KICKPIPES MAY BE SURFACE MOUNTED WHERE A SAVINGS WILL RESULT. CABLE CLEARANCE HOLES MAY BE CUT BY BURNING EXCEPT FOR THE FOLLOWING STRUCTURE WHICH SHALL BE DRILLED OR MECHANICALLY CUT SO AS TO BE SMOOTH & FREE OF CRACK TRIGGERING NOTCHES:

(1) BALLISTIC STRUCTURE
(2) TORPEDO DEFENSE SYSTEM BULKHEADS
(3) SHELL PLATING
(4) UPPERMOST STRENGTH DECK

SEE SECTION 4 SHEETS 11 & 14

SUPERSEDES SHEET K

NAVY DEPARTMENT — BUREAU OF SHIPS — WASHINGTON D.C.

ELECTRIC PLANT INSTALLATION
STANDARD METHODS
GENERAL NOTES

SECTION I SHEET E

NObs-55369

9000 | S6202 | 73980 | G

SCALE NONE

Copy available to DDC does not permit fully legible reproduction

REV B: ADDED NOTES 45A & 55
WAS SHEET L.
REV C: REVISED NOTES 44A & 44D. DELETED [illegible]
REV D: REVISED NOTE 55
REV E: REVISED NOTES, 39, 45, [illegible]
REV F: REVISED NOTE 50. DELETED NOTE 51

WOOD STRUCTURE MOUNTING

37-DIAMETER OF LEAD HOLE FOR LAG BOLTS, WOOD SCREWS OR SELF TAPPING SCREWS SHALL BE APPROXIMATELY 70 PERCENT AND 90 PERCENT OF THE DIAMETER AT THE ROOT OF THE THREAD FOR SOFT WOODS AND HARD WOODS RESPECTIVELY.

BALLISTIC, STS STRUCTURE MOUNTING

38-IN ALL METHODS OF ATTACHMENT TO BALLISTIC DECKS AND BULKHEADS SHOWN ON THIS DRAWING, THE TERM "BALLISTIC" REFERS TO SPECIAL TREATMENT STEEL (STS) PLATING.

39-BALLISTIC METHODS DETAILED HEREIN FOR ATTACHING FITTINGS AND FIXTURES ETC (EXCEPT CABLES) TO BALLISTIC SURFACES SHALL BE USED ONLY WHEN THE BALLISTIC PLATING IS FIFTY (50) POUNDS PER SQUARE FOOT OR 1-1/4 INCHES IN THICKNESS AND OVER. VITAL INSTRUMENTS AND EQUIPMENT SHALL BE KEPT CLEAR OF SUCH SURFACES SUCH AS BY MOUNTING ON A PLATE SUPPORT SUCH AS METHOD 331 INSTALLED 2 INCHES CLEAR OF THE BALLISTIC PLATE.

40-CABLE PENETRATIONS OF SPECIAL TREATMENT STEEL PLATING SHALL CONFORM TO THE REQUIREMENTS FOR BALLISTIC INSTALLATIONS.

GUN BLAST AREAS

41-WHERE NECESSARY TO ATTACH ELECTRICAL FITTINGS AND FIXTURES TO DECKS OR BULKHEADS WITHIN GUN BLAST AREAS, SUCH EQUIPMENT SHALL BE MOUNTED ON EXTENSION HANGERS PROVIDING A 2 INCH MINIMUM CLEARANCE BETWEEN THE STRUCTURE AND EQUIPMENT AND MOREOVER SUCH EQUIPMENT SHALL BE LOCATED CLEAR OF AREAS OF MAXIMUM EXPECTED DEFLECTION OR WHIP OF BULKHEAD AND DECK PLATING IN ORDER TO PREVENT BREAKAGE OR PULLING LOOSE OF MOUNTING FEET.

SEALERS AND COMPOUNDS

42-ALL THREADS ON BOLTS, SCREWS, NUTS ETC USED IN CABLEWAYS AND CABLE SUPPORTS AND FOR THE SUPPORT OF ELECTRICAL EQUIPMENT IN TOPSIDE LOCATIONS EXPOSED TO THE WEATHER SHALL BE COATED WITH ANTI-SEIZE COMPOUND EXCEPT THAT ON ALL INSTALLATIONS THREADED PARTS OF ALUMINUM, WHETHER ALUMINUM TO ALUMINUM OR ALUMINUM TO OTHER METAL, SHALL BE COATED WITH A ANTI-SEIZE COMPOUND OF A MIXTURE OF 50 PERCENT ZINC DUST AND 50 PERCENT PETROLATUM BEFORE ASSEMBLY.

43-PIPE THREADS ON ELECTRIC CABLE STUFFING TUBES, KICKPIPES AND STUFFING TUBE SEALING CAPS SHALL BE COATED WITH SEALING COMPOUND IN ACCORDANCE WITH SPECIFICATION MIL-S-15204 BEFORE ASSEMBLY.

44-AFTER THE CABLES ARE PROPERLY SECURED, PLASTIC SEALER ELECTRICAL INSULATION, MILITARY SPECIFICATION MIL-I-3064, TYPE HP, SHALL BE USED TO SEAL THE SPACE AROUND THE CABLE AS FOLLOWS.

A- IN CABLE CLAMPS AND BUSHINGS ENTERING THE TOP OF AN ELECTRICAL ENCLOSURE.

~~[illegible] THE GLAND NUTS ONLY AFTER THE TUBES ARE PACKED AND THE GLAND NUTS SET UP~~

~~C- BOX CONNECTORS AND BUSHINGS AT ENCLOSURE ENTRANCES.~~

D- IN BUSHINGS OR DRILLED HOLES USED FOR PASSING CABLES THROUGH LIGHT TIGHT AND FUME-TIGHT BULKHEADS.

45-WHEN DECK COVERING IS USED WITH NON-WATERTIGHT RISER BOXES FILL DECK AREA WITHIN THE RISER BOX WITH BITUMINOUS EMULSION COATING SPECIFICATION MIL-C-15203 TO THE LEVEL OF THE DECK COVERING.

45A- IN WET & HUMID AREAS, CREVICES RESULTING FROM SINGLE FILLET WELDS OF KICKPIPES, PASSING THRU DECKS & BULKHEADS, SHALL BE GIVEN ONE OF THE FOLLOWING CORROSION PROTECTIONS.

(1) DOUBLE WELD

(2) BITUMASTIC COMPOUND FED SPEC TT-C-520. THIS METHOD SHALL NOT BE USED WHERE AMBIENT TEMPERATURES EXCEED 110°F.

(3) STRONG BACK PUTTY "CORDO BOND", CORDO CHEMICAL CORP, NEWARK, NEW JERSEY, OR EQUIVALENT.

PAINTING AND PLATING

46-ALL SUPPORTING STRUCTURE FOR CABLES, FIXTURES, PANELS, APPLIANCES, ETC (INCLUDING BOLTS, NUTS, SCREWS AND SHEETS OR PLATES USED FOR MECHANICAL PROTECTION ETC) SHALL BE PAINTED IN ACCORDANCE WITH NAVSHIPS REQUIREMENTS. AFTER BEING FORMED OR WELDED, ZINC PLATING MAY BE SUBSTITUTED FOR THE PRIME COAT OF ALL SUCH MATERIAL, OR PARTS, THEREOF, SUCH AS SCREWS, NUTS, ETC.

[redacted]

48-THE FAYING SURFACES OF ELECTRICAL FITTINGS AND CABLE SUPPORTS OF STEEL OR ALUMINUM WHERE MOUNTED ON STEEL OR ALUMINUM DECKS, BULKHEADS, PLATES, ETC SHALL BE PAINTED IN ACCORDANCE WITH NAVSHIPS REQUIREMENTS.

49-ALUMINUM IN CONTACT WITH WOOD SHALL BE PAINTED IN ACCORDANCE WITH NAVSHIPS REQUIREMENTS.

GROUNDING METHODS

50-GROUNDING OF ELECTRICAL EQUIPMENT FRAMES, ENCLOSURES CABLE ARMOR (IF REQUIRED), AND SUPPORTS SHALL BE IN ACCORDANCE WITH MIL-STD-1310.

51-[redacted]

MAGNETIC EFFECTS

52-SUBMARINE ELECTRIC PROPULSION INSTALLATION SHALL BE IN ACCORDANCE WITH THE METHODS SHOWN HEREIN.

53-SURFACE SHIP ELECTRIC PROPULSION INSTALLATION SHALL BE IN ACCORDANCE WITH THE METHODS SHOWN HEREIN.

54-WITHIN THE MAGNETIC CIRCLE, SUPPORTS FOR CABLES, FIXTURES, FITTINGS ETC SHALL BE ALUMINUM, BRASS, OR CORROSION RESISTANT STEEL OF THE AUSTINETIC TYPE. THE MATERIAL USED SHALL BE THAT WHICH IS BEST SUITED TO THE SHIPS STRUCTURE AND THE EQUIPMENT BEING SUPPORTED.

CABLE SUPPORT MATERIALS

55-CABLE SUPPORT COMPONENTS SHALL BE OF THE FOLLOWING MATERIALS.

NON MAGNETIC VESSELS
HANGERS - ALUMINUM
SUPPORTS - ALUMINUM

FERRULES - CRES OR ALUMINUM
BOLTS & NUTS - CRES OR ALUMINUM

OTHER VESSELS
HANGERS - ALUMINUM OR STEEL
SUPPORTS - ALUMINUM OR STEEL

BOLTS & NUTS - STEEL ZINC OR CADMIUM PLATED

SUPERSEDES SHEET L.

NAVY DEPARTMENT	WASHINGTON DC
NAVAL SHIP ENGINEERING CENTER	
EXAMINED / OFFICIAL SIGNATURE	ELECTRIC PLANT INSTALLATION STANDARD METHODS
	GENERAL NOTES
SECTION 1 SHEET F	NAVSEC NUMBER 9000 S6202 73980 F
	SCALE - NONE

GENERAL NOTES (CONTINUED)

PROCEDURES FOR CABLE INSTALLATIONS ON NAVAL VESSELS

REV / REVISIONS
A FIRST ISSUE
B ADDED GENERAL NOTE 13
REVISED NOTES 1 AND 10 [illegible]

1. CABLE INSTALLATION SHALL BE IN ACCORDANCE WITH METHODS SHOWN HEREIN.

2. THE CABLE SUPPORT* METHODS SHOWN HEREIN ARE TO BE USED ONLY AS A GUIDELINE IN THE DEVELOPMENT OF WIREWAY SUPPORTING SYSTEMS CAPABLE OF SATISFACTORY CABLE SUPPORT. USE OF DETAILED AND IDENTIFIABLE ITEMS HEREIN IS NOT REQUIRED. ANY CABLE SUPPORT METHOD, DEVICE OR SYSTEM CAN BE USED PROVIDING THE FOLLOWING IS ACHIEVED:
   a. RESISTANCE TO SHOCK-MIL-S-901
   b. RESISTANCE TO VIBRATION-MIL-STD-167
   c. MINIMUM WEIGHT.
   d. MINIMUM COST.
   e. MAXIMUM USE OF INDUSTRIAL MILL AND COMMERCIAL NON-PROPRIETORY ITEMS FOR MINIMUM SURVEILANCE DURING INSTALLATION.
   g. MINIMUM MAINTENANCE ON CABLE SUPPORTING SYSTEMS.
   h. FACILITATE CABLING PROCEDURES.
   i. CONVENIENCE OF SERVICING CABLING SYSTEM.
   j. FIREPROOF UNLESS EXCEPTED IN SPECIFIC AREAS SUCH AS WOOD SHIPS.
   k. MATERIAL USED IS NON TOXIC UNDER ALL CONDITIONS.
   l. FREE OF SHARP PROTRUSIONS, CORNERS, ITEMS, ETC., DANGEROUS TO PERSONNEL.
   m. SHALL BE SO DESIGNED TO PERMIT REPAIR WITH LOCAL MARKET ITEMS. IT IS NOT INTENDED THAT EXTENSIVE BACK-UP STOCKS BE SUPPLIED FOR ITEM BY ITEM REPLACEMENT.
   n. COMPATIBLE WITH AND NON-DAMAGING TO CABLES.

   * (NOTE: USE OF INSULATING SPACER BLOCKS IS MANDATORY FOR PROPULSION CABLES TO PREVENT BUNCHING.)

3. ALL CABLE SUPPORTING ARRANGEMENTS SHALL BE TESTED FOR RESISTANCE TO SHOCK AND VIBRATION. DEFORMATION TO SUPPORTING MEMBERS AND RETAINING MEMBERS IS SATISFACTORY PROVIDING CABLES ARE PREVENTED FROM BECOMING WHIPS OR MISSILES AND RETAINERS RACKS AND SUPPORTS DO NOT BECOME MISSILES. SHOCK AND VIBRATION TESTS SHALL BE CONDUCTED AT A RECOGNIZED LABORATORY. NO MECHANICAL DAMAGE SHALL OCCUR TO CABLE SPECIMENS AND INSULATION RESISTANCE SHALL COMPLY WITH SPEC MIL-C-915. COPIES OF THE TEST REPORT, CERTIFIED BY THE GOVERNMENT INSPECTOR WITNESSING THE TEST, SHALL BE FORWARDED TO THE ATTENTION: NAVSHIPS/NAVSEC, SEC 6157E. COPIES SHALL ALSO BE FURNISHED PURCHASING ACTIVITIES UPON REQUEST. THESE TESTS SHALL BE CONDUCTED ANNUALLY, OR IF RATE OF SALES (PERIODS IN EXCESS OF THIS TIME FRAME) ARE SUCH, THEN TESTS SHALL BE CONDUCTED FOR EACH CONTRACT. MATERIAL IS NOT SATISFACTORY UNLESS IT HAS SUCCESSFULLY

3. (CONT) PASSED THESE TESTS. SHOCK TESTS SHALL BE IN ACCORDANCE WITH SPEC MIL-S-901, GRADE A. VIBRATION TESTS SHALL BE IN ACCORDANCE WITH SPEC MIL-STD-167. CABLE SUPPORTING DEVICES SHALL BE ARRANGED FOR TESTING AS FOLLOWS:
   a. MULTIPLE CABLE TEST RACKS (15 INCHES FREE LENGTH OF CABLE SUPPORT).
      (1) IF MULTIPLE CABLE RACKS ARE BEING TESTED FOR ABILITY OF CABLE SUPPORT MEMBER ONLY TO WITHSTAND SHOCK AND VIBRATION AS FULLY LOADED, A MINIMUM OF 3 SUPPORTING STATIONS WITH 32", 21" OR 16" SPACING SHALL BE PROVIDED. THE MAXIMUM NUMBER OF THE LARGEST CABLES THAT CAN BE ACCOMODATED ON THESE RACKS SHALL BE APPLIED. CABLE OVERHANG AT EACH END SHALL BE 16" OR 1/2 THE DISTANCE BETWEEN SUPPORTS.
      (2) IF TIERS OF MULTIPLE CABLE RACKS AND SUPPORTING DEVICES FOR ATTACHMENT TO SHIPS STRUCTURE ARE TO BE TESTED FOR CAPABILITY TO WITHSTAND SHOCK AND VIBRATION, A DUPLICATE OF THE ASSEMBLY PROPOSED FOR SHIPBOARD INSTALLATION WITH A MINIMUM OF 3 SUPPORTING STATIONS WITH 32", 21" OR 16" SPACING SHALL BE PROVIDED. THE MAXIMUM NUMBER OF THE LARGEST CABLES THAT CAN BE ACCOMODATED ON THESE RACKS SHALL BE APPLIED. CABLE OVERHANG AT EACH END OF RACK SHALL BE 16" OR 1/2 THE DISTANCE BETWEEN SUPPORTS.
   b. SINGLE CABLE SUPPORTS.
      ALL SINGLE CABLE SUPPORTS, INCLUDING THOSE CONFORMING TO FED SPEC FF-S-760 SHALL BE TESTED. THESE SHALL BE ARRANGED USING A MINIMUM OF 3 SUPPORTING STATIONS SPACED 32", 21" OR 16" APART. CABLE OVERHANG SHALL BE 16" OR 1/2 THE DISTANCE BETWEEN SUPPORTS. MAXIMUM SIZE CABLES SHALL BE MOUNTED WITH THESE SINGLE CABLE SUPPORTS.
   c. TWO, THREE OR FOUR CABLES SUPPORTED AS SHOWN ON SHEET 196, SECTION 2, OR BY USE OF RETAINER BARS OR STRAPS SHALL BE ARRANGED FOR TESTS IN A MANNER SIMILAR TO THAT FOR SINGLE CABLES.
   d. A SINGLE ROW OF CABLES SHALL BE ARRANGED AS DESCRIBED FOR MULTIPLE CABLE RACKS.

4. CABLE RETENTION.
   DEVICES FOR CABLE RETENTION ARE NOT REQUIRED ON HORIZONTAL CABLE SUPPORTS IN MULTIPLE RACKS. IF RETENTION OF CABLE ON OVERHEAD HORIZONTAL SUPPORTS IS REQUIRED, THIS CAN BE ACCOMPLISHED BY THE USE OF RETAINERS SUCH AS CONTOUR STRAPS, OR SOFT IRON FLAT BARS BENT OVER THE CABLES, SEMI-CONTOUR STRAPS OR ANGLE IRON RETAINERS. ON CABLE RUNS IN WHICH THE SUPPORT MEMBER IS VERTICAL OR ON CABLE RUNS IN WHICH THE CABLE IS VERTICAL (BOTH CASES BEING BULKHEAD MOUNTED) CABLE RETENTION IS NECESSARY. CABLES OF A SINGLE ROW WOULD BE REQUIRED TO BE RETAINED. WHERE CABLES WOULD BE SUBJECTED TO PHYSICAL FORCES SUCH AS ON SHEETS 158 AND 159 (SECTION 2), RETAINERS ARE REQUIRED.

5. SPACING OF STEEL AND ALUMINUM CABLE SUPPORTS SHALL BE 32 INCHES EXCEPT AS FOLLOWS:
   (1) THE SPACING OF HANGERS SHALL BE 21 INCHES TO REDUCE CABLE SAG IN CABLE RACKS WHEN HEADROOM CLEARANCE UNDER THE CABLE RACKS BEFORE INSTALLATION OF CABLES IS 6'7" OR LESS (6'4" MINIMUM.)
   (2) HANGERS FOR OVERHEAD MULTIPLE TIER ALUMINUM WIREWAYS, WHEN WELDED TO ALUMINUM DECKS SHALL BE SPACED 16 INCHES AND THE NUMBER OF TIERS SHALL BE LIMITED TO THREE.
   (3) THE SPACING OF HANGER SUPPORTS FOR SINGLE CABLES OR SINGLE ROW OF CABLES SHALL IN GENERAL BE 32 INCHES BUT MAY BE ADJUSTED BETWEEN 32 AND 16 INCHES AS NECESSARY TO SUIT PARTICULAR SHIP CONDITIONS.

6. A MAXIMUM OF FIVE ROWS OF CABLES MAY BE SUPPORTED FROM AN OVERHEAD DECK IN ONE CABLE RACK EXCEPT AS INDICATED IN NOTE 5(2) ABOVE.

7. A MAXIMUM OF TWO ROWS OF CABLES MAY BE SUPPORTED FROM BULKHEADS IN ONE CABLE RACK.

8. SIXTEEN ROWS OF CABLES MAY BE SUPPORTED IN MAIN CABLEWAYS IN MACHINERY SPACES AND BOILER ROOMS.

9. CABLE HOLD DOWN DEVICES ON HORIZONTAL CABLE RUNS CONFINED WITHIN HORIZONTAL CABLE SUPPORTING STRUCTURE (THE CABLE SUPPORT BEING HORIZONTAL) ARE NOT REQUIRED.

10. DOUBLE BANKING OF CABLES NOT APPROVED EXCEPT IN SPECIAL CASES AS SHOWN HEREIN.

11. BACKING PLATES ARE NOT REQUIRED FOR CABLE SUPPORT EXCEPT THAT WHEN BULKHEADS ARE 1/16" THICK OR LESS AND CABLE RUN IS OVER 4" IN WIDTH, BACKING WASHERS SHALL BE USED.

12. MULTIPLE ROWS OF CABLE SHALL NOT EXCEED TWO ON BULKHEADS EXCEPT IN CONGESTED LOCATIONS IN WHICH CASE 3 ROWS MAY BE USED ON REQUEST AND SUBJECT TO SPECIFIC APPROVAL.

13. CABLE SUPPORT ANGLES PC 1382, [illegible] 3/16" STEEL, SHALL BE SECURED TO SHIP STRUCTURE BY 180-DEGREE WELD EXCEPT THAT IN THE FOLLOWING CASES THE WELD SHALL BE 360-DEGREES.
   A. WHERE THE NUMBER OF TIERS OF 15-INCH CABLE ROWS IN WIREWAY EXCEEDS TWO.
   B. WHEN WELDING TO BALLISTIC STRUCTURE.
   C. WHEN THE WELDS ARE IN WET SPACES SUCH AS WEATHER DECKS OR SHOWER ROOMS.

NAVY DEPARTMENT — BUREAU OF SHIPS — WASHINGTON, D.C.

ELECTRIC PLANT INSTALLATIONS
STANDARD METHODS

GENERAL NOTES

SECTION 1
SHEET G

9000 | 56202 | 73980 | B

SCALE

Copy available to DDC does not permit fully legible reproduction